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TRENDS IN U.S. AIR FORCE TACTICAL FIGHTER LIFE CYCLES

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Number 11

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PEACE STUDIES PROGRAM OCCASIONAL PAPER NO. 11

April 1979

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

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I. INTRODUCTION

After reviewing the report of the Defense Science Board's 1977 Summer Study on the Acquisition Cycle, Deputy Secretary of Defense Duncan asked for suggestions and recommendations as to how to improve the acquisition process by reducing the length and cost of the cycle.[1] Since that request and its responses, concern has become more widespread. Many agree with the Defense Science Board's conclusions: i.e., weapons systems are more costly, take longer to become operational, and are produced under less than optimum circumstances. The inference is that things are getting worse. Remember the good-old-days, pre-McNamara of course, when development times were short, production rates were high and weapons systems were cheap. The good-old-days when the program manager and the contractor could work together without being encumbered with magic management schemes and reviews and could get the job done. But wait a minute: you've no doubt heard of fly-before-buy programs, but have you ever heard of the Craig-Cook production plan?[2] It was "fly-before-buy" circa 1951, and it called for limited production at first, in conjunction with early flight testing and correction of deficiencies, followed by accelerated production. So, before generalizing about the good-old-days of acquisition programs, it's good to examine the historical record in some detail to determine where you are, relative to those "good-old-days."

Scope. It is intended here to do just that; to make some generalizations about where we are relative to where we were. The study is limited to United States Air Force jet fighter development programs, a set of systems for which comparable program data have been compiled. Although it is hard to purify these program data entirely of external influences such as foreign military sales, other tactical applications, and world events, the intent here is to examine only those aircraft types which were purchased for and operated by the United States Air Force. As such, this study covers 19 tactical jet aircraft types which have been in active Air Force inventory from 1945 to 1979.

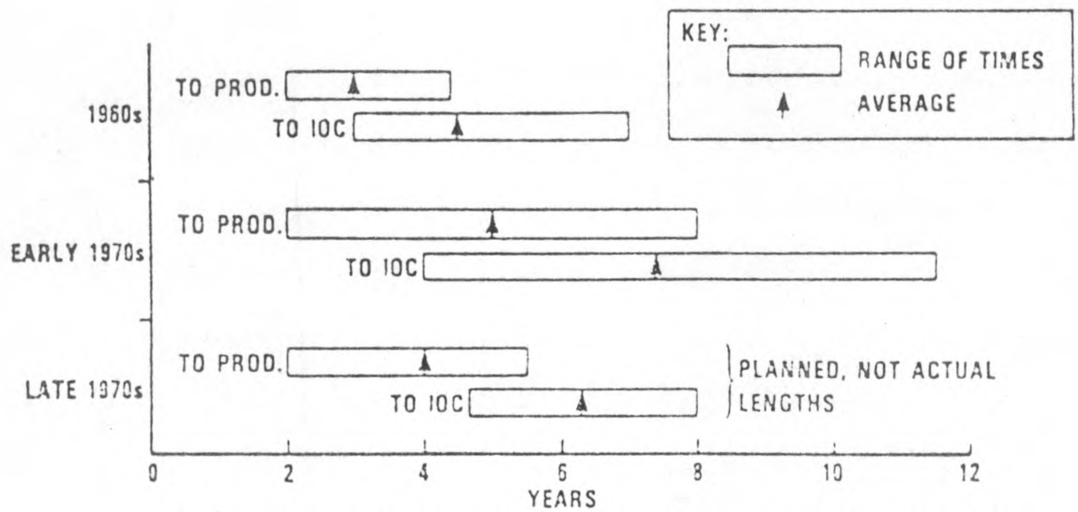
From those 19 types, starting with the first really operational jet, the F-80, to the latest, the F-16, the lengths and trends in development cycles, the lengths and rates of production and deployment cycles, and the cost trends will be examined. There has been considerable discussion of these areas, but that discussion has been based on generalized aggregate data.

For instance, Dr. Perry, US DR&E, said in his statement to Congress on the FY 80 Program for Research, Development and Acquisition that there has been an average increase of nine percent per year in the cost of fighter aircraft systems.[3] This is an accurate generalized statement, but it obscures the fact that there is a significant difference in the cost growth of the different mission areas of air superiority, close air support, and all weather interdiction. There is also a significant difference in the cost growth trends of the highs and the lows of the so called high-low mix. And there may be a difference in the cost growth of Navy and Air Force types of aircraft.

The Under Secretary of Defense for Research and Engineering is also concerned about the increased acquisition time of weapons systems.[4] Here the concern is that it is taking longer to get to the initial operational capability (IOC) of equipment, with the result that such equipment may embody outdated technology when it is fielded. Perry's report argues that there has been little change in the time from the beginning of full scale development to first flight,[5] but that there has been a significant increase in the time to get to full production and deployment. (See Figures 1 and 2) Here again, all systems, types, and models are lumped together when, in

Figure 1

LENGTHENING TIME FROM FULL SCALE DEVELOPMENT TO DEPLOYMENT

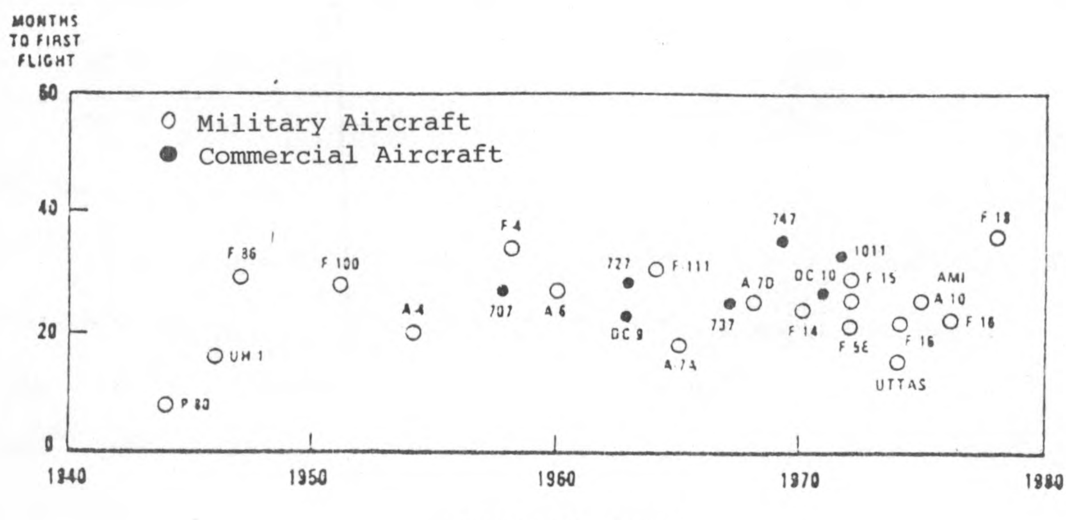


TIME FROM START OF FULL SCALE DEVELOPMENT TO ENTERING PRODUCTION AND TO IOC

DATA INCLUDES DEVELOPMENT OF MOST FIGHTERS, HELICOPTERS

Figure 2

TIME FROM FULL SCALE DEVELOPMENT CONTRACT AWARD TO FIRST FLIGHT



Source: Department of Defense, The FY 80 Program for Research, Development and Acquisition (Washington: U.S. Govt. Print. Off., 1979), p. 8.

fact, there are significant differences in the full scale development time for systems, with such time depending upon the lead-in work done on the systems in preparation for full scale development. This is not intended as a new relevation, but more as a reminder that the designation of the beginning of full scale development may vary widely and does not necessarily indicate equal development maturity among the programs.

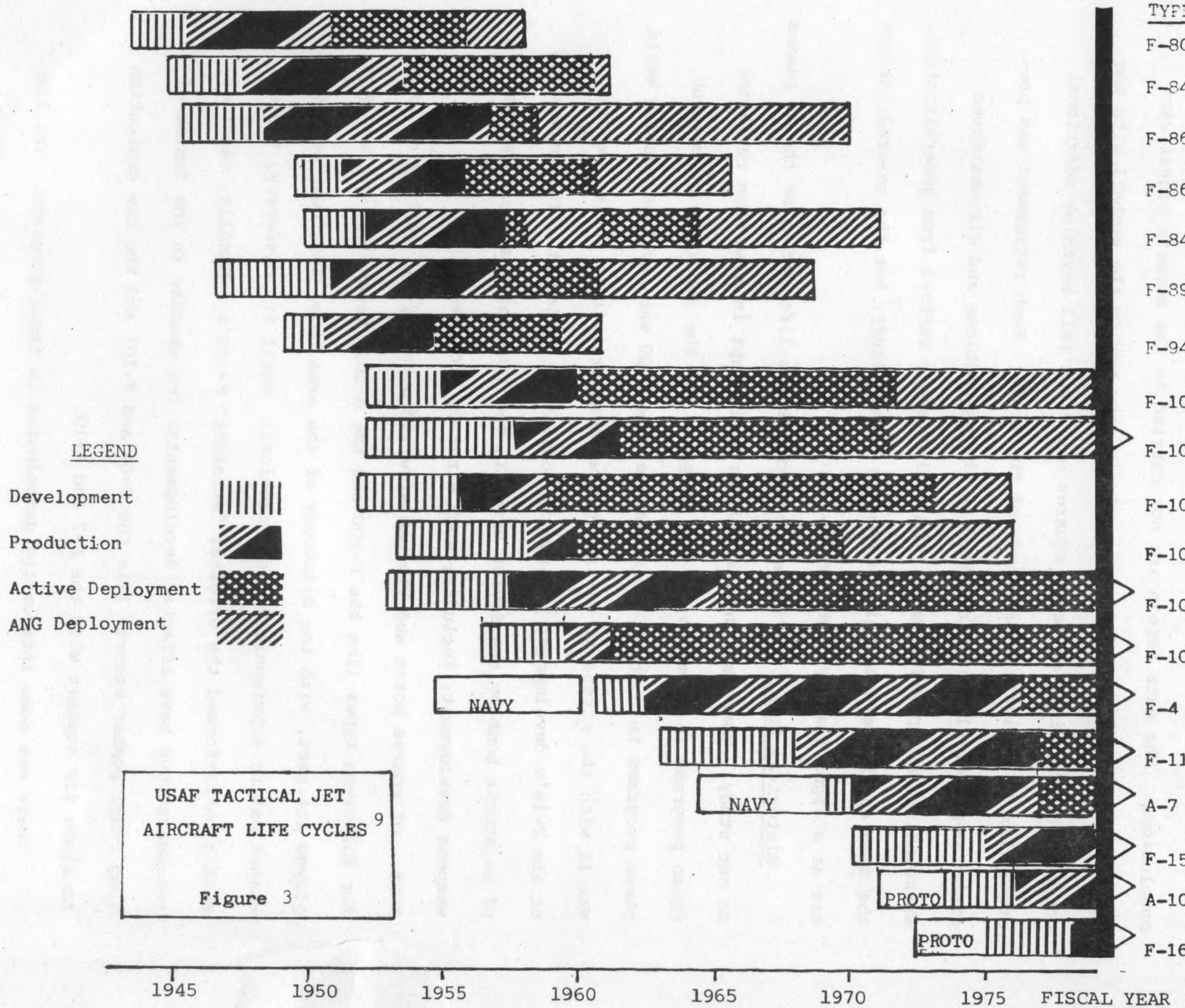
With fewer aircraft types going into the inventory and fewer numbers of each type procured, plus the fact that no new developments are imminent, the lives of our current aircraft may have to be longer and they may have to be adapted to new roles. Is the policy of "advancement of existing airframes" a new phenomenon?[6] Hardly. In this study there are some interesting cases discussed, and there are indications that, historically, airframe adaptions are short lived.

Someone already probably has caught the "19 types" and said to himself that there are only 17 types: thus the first of many problems of definition. The division here is into 19 types and includes the F-84F and the F-86D as separate types. These two types are considered sufficiently different from the basic airframes to be treated as completely separate programs. At one time the Air Force did too, in that it called the F-84F the F-96A and the F-86D the F-95A. Of course the question then is: why wasn't the F-94C separated, since it was originally the F-97A? In this case the F-94C was the only really successful version of the F-94, life of the type was relatively short, and breaking it out separately would not have had a significant effect on the trends.

At this point a word should be said about the limitations of this study. It is not intended that the results have precise numbers and data. Such a study would be a large volume of a variety of cases, assumptions, and conclusions. The data herein are not carried to the seventh significant digit. Least squared regression analysis gave way to the eyeball with the notion that the rigor of least squares would not tell anything additional other than to refine the magnitude of the trend. Such refinement and precision could easily be overwhelmed by the assumptions and circumstances surrounding any specific case. Thus, this study suffers from generalization, the same as the Defense Science Board's Summer Study,[7] but the generalizations are at a significantly lower level.

Historical Notes.[8] Figure 3 summarizes the life cycles of the 19 planes in our study. There are several events to be kept in mind when reviewing these programs in order to put the programs and the decisions concerning these programs in context. For example, the F-80 was developed during World War II with the attendant wartime procurement practices, while the context of the F-16's development program is completely different. The detonation of an atomic bomb by the Soviet Union in the late forties caused a spurt in weapons development, including such aircraft programs as the F-89 and the F-94. Of course Korea and Vietnam affected quantity and quality decisions for follow-on types like the F-100 and the A-10. Technology certainly played its part, with the discovery of the area rule (the "coke-bottle" shape) making supersonic flight practical. Until its discovery, the old F-86's outperformed the original "straight" F-102's. Finally, tactical considerations have affected developments; for example in the demise of long range bomber escorts like the F-84 and F-101 and the new dedication to close air support with the A-7 and A-10.

There are some interesting geneologies in these programs. The Air Force A-7D started as a Navy A-7 which was derived from the Navy F-8. Such derivation was directed by Secretary McNamara as a means of cutting



USAF TACTICAL JET AIRCRAFT LIFE CYCLES[9]

Figure 3

development costs and time. The old F-94 was derived from the T-33 which was derived from the F-80. By the time this evolution was through, a day fighter had become a "supersonic" all-weather interceptor, armed with rockets and with an afterburning engine. Though there is a traceable geneology, the actual interchangability of parts had dimished to something like altimeters, landing gear doors and tail surfaces. Tooling for the F-84F was to be 55% common with the previous F-84's, even though it introduced a swept wing to the F-84 series. It turned out to have hardly anything in common with the straight-wing 84's.

The active lives of the types has varied considerably. The F-84F was overtaken by technology and was phased out of active service only 11 months after the last aircraft was accepted by the Air Force. At the other extreme is the F-106 which is still in service 19 years after the last delivery.

The requirements process has some interesting events also. The original TFX requirement stipulated vertical take off. Be thankful we didn't have to pay for that, too. Then, there is the case of the F-106 where the requirement really was not made final until 3 months before first flight, a sure way to have the requirements and performance nearly match. (There is one better -- wait until after first flight.)

One final note, the A-10 could be said to have nearly had both the longest and the shortest development program; it depends on how you count the prototype program in full scale development. If the prototype program is excluded, the A-10 has had the shortest full scale development since the F-84 series. If the prototype program is included, the A-10 program has had the longest development program except for the F-4 and F-16. Each case should be examined in the proper context.

The history of these fighter programs is filled with what appears to be inconsistencies and poor decisions. However, taken in the context of the events and circumstances surrounding such programs, such inconsistencies and decisions often are understandable, even if you do not agree with the judgment.

II. DEVELOPMENT CYCLES

In his overview statement to Congress on the FY 80 Program for Research, Development and Acquisition, Dr. Perry said there are indications that the average acquisition time for several different kinds of weapons programs has increased from 4½ years in the 1960's to over 7 years in the 1970's.[10] The time from the start of full scale development to the start of production and the IOC is growing for most aircraft programs while, at the same time, the time from the start of full scale development to first flight has not changed appreciably. The conclusion is that the lengthening times to deployment is due to increased testing and the strict sequencing of development, testing and production rather than overlapping these activities.[11]

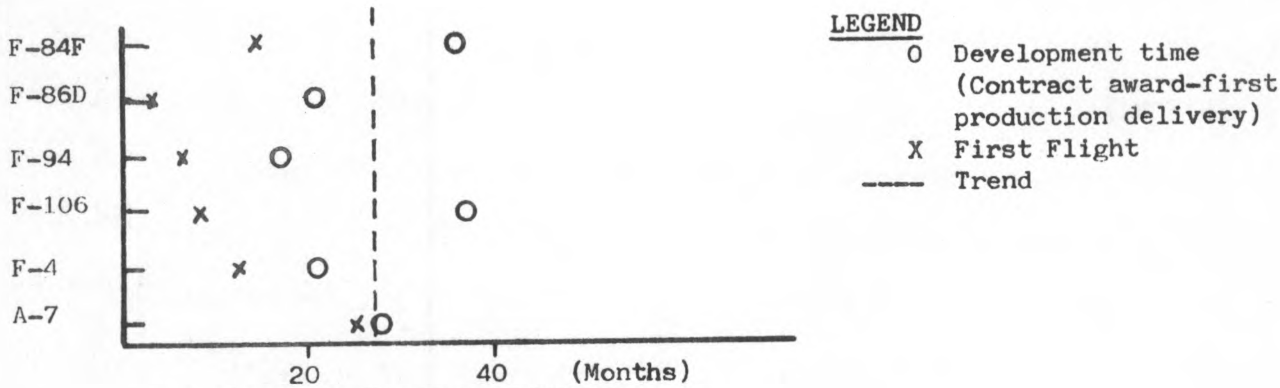
Defining the time it takes to develop a system is subject to debate. First, when did development start? By convention, it starts on the date of the full scale development contract, and this is about the only date which has a common meaning. However, not all development programs are at the same stage when the contract is awarded, and this is one cause of the wide variance in the time to first flight.

Many activities go on before the award of the full scale development contract. Obviously the proposal preparation contributes to the development. There are studies and analyses. There are technologies developed under other programs which are incorporated. These and other activities contribute to the development process and may or may not be included in the full scale development time. The one thing common with the award of a full scale development contract, no matter what the stage of the development thus far, is the decision to produce a fully operating model and to test its operational capabilities. It is a point of standard commitment, and is used in this study as the beginning of full scale development.

The next question is when to end the development. A common date to use is the initial operational capability (IOC) date. From the standpoint of the service it is an excellent measure, the time when the first unit of men and machines are combat ready. From a purely hardware development standpoint, the delivery of the first production aircraft to an operational unit is a key milestone and a better measure. By using the first delivery date, factors such as production rate, arbitrary definition of IOC, and training time are eliminated. It is further granted that there is overlap of the end of full scale development and the beginning of production, and the amount of concurrency varies from program to program. But any milestone used is subject to definition and debate; therefore, for the purpose of this study, full scale development is defined as being the period of time from contract award to first production delivery.

There seems to be a logical division amongst the 19 types. It is not, as you might suspect, based on time or technology. At least you cannot make that generalization across-the-board. Instead, the three divisions are: variants of previous production systems, variants of previous experimental systems, and new starts. Though breaking the small number of programs into three creates even smaller subsamples and may not be in keeping with rigorous analysis, it does reveal some interesting trends.

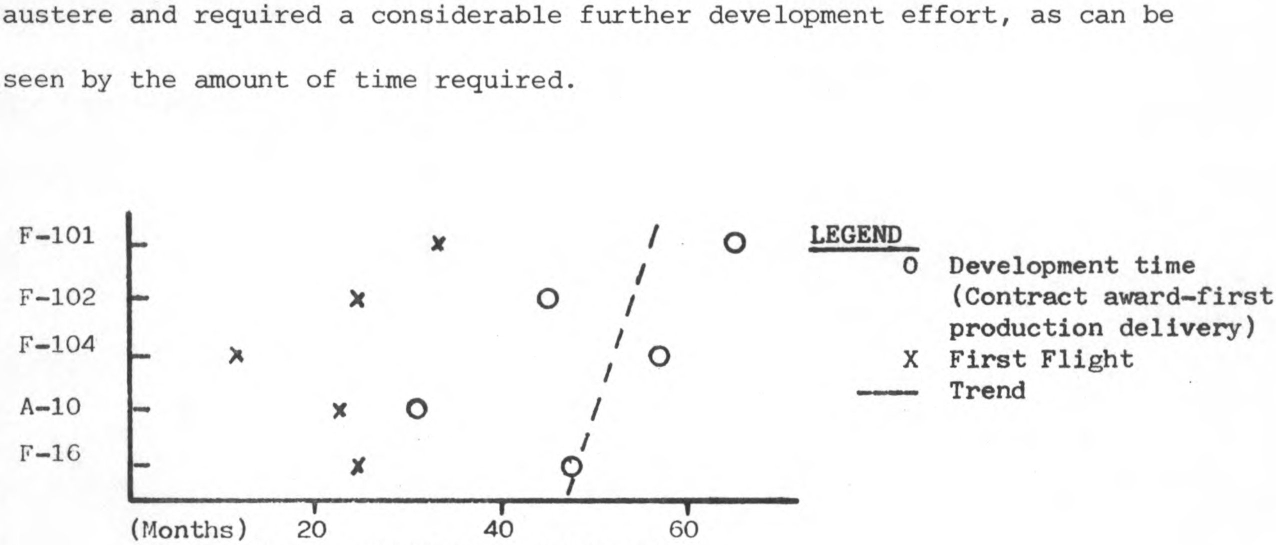
First, the variants of previous production systems (Figure 4) seem to have a fairly level trend in the amount of time it takes for development. This sample, you will note, even includes the F-106 and counts the time-to-develop a F-106 as we know the F-106 to be today. It seems to matter little whether it was a relatively simple change from the production version such as the F-4B to F-4C or a relatively complex change such as changing the engine and avionics suite of the A-7; it takes on the average two years, give or take a couple of months, for full scale development.



AIRCRAFT ACQUISITION INTERVALS[12]
VARIANTS OF PRODUCTION MODELS

Figure 4

The second subgroup, variants of previous experimental aircraft (Figure 5), also shows a trend. Here there may be some question about using only the full scale development time, excluding the prototype phase of the A-10 and F-16 in the sample. Realistically, these prototype programs do equate to such aircraft as the XF-88 and the XF-92, predecessors of the F-101 and F-102 programs respectively. The prototypes of the A-10 and F-16, though closely resembling the final configuration aerodynamically, were austere and required a considerable further development effort, as can be seen by the amount of time required.



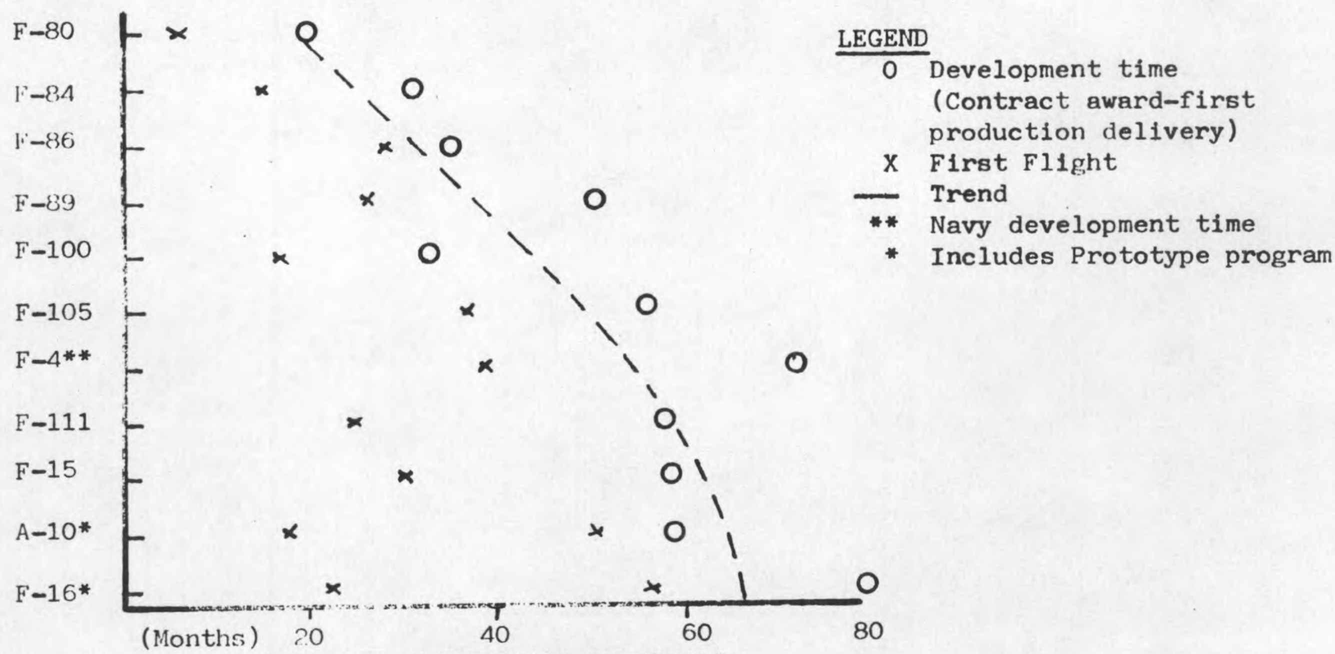
AIRCRAFT ACQUISITION INTERVALS[13]
VARIANTS OF EXPERIMENTAL MODELS

Figure 5

Once the decision was made to begin full scale development there was a rather large development effort. The conclusion is that there is a favorable trend in development time for variants of previous experimental aircraft programs, and this is largely due to the F-16/A-10 experience.

What remains is new-start programs (Figure 6), and the findings associated with these types of programs. Here the A-10 and F-16 total development times, including the prototype phase, are included. Although these two programs may affect the magnitude of the outcome, they do little to influence the trend. The trend here is unmistakably to longer development times. Some of this time may be because of measures instituted to reduce risk and better prepare for production and some may be simply different bookkeeping.

A case could be made that the length of the present day development programs equate to the "real" development times of earlier aircraft. The



AIRCRAFT ACQUISITION INTERVALS NEW DEVELOPMENTS [14]

Figure 6

earlier programs were all plagued with extensive modification and retrofits after the aircraft had entered the inventory. As a matter of fact it was usually the B, C and D models of the system which had the largest production quantity and longest service life. This suggests, and in fact was the case in one instance, that the A's were still development aircraft. Thus, if the development times of earlier programs were in fact longer than indicated, the development times for new starts probably have grown, but not by as much as is commonly believed.

Thus, if all the operational types are considered, a case can be made that there has been little or no growth in the average development times of aircraft. The manner in which one treats the development time of the A-10 and F-16 influences the outcome somewhat. With the current policy, as stated by the services, of modification of existing airframes, one can estimate that the "new" developments in the near future will take on the order of two years. Development programs to replace the present generation of aircraft will take on the order of 66 months, prototype or not, if there is no urgency or technological breakthrough. If there is a technological breakthrough, based on the enhanced tactical fighter studies which are currently ongoing, and an experimental aircraft is used to lead a new development, then it should be estimated that such development time would take approximately 48 months. Thus the urgency of the program and the technological advancement required may be traded off to govern the length of the development time for the next generation tactical fighter aircraft.

III. PRODUCTION CYCLES

Program offices put a good deal of effort into designing optimum production facilities, with rates, quantities, and types influencing the process. Facilities are designed to produce at a certain rate, but external factors, like Congress, frequently take over and ignore all the preparation. Since the final production rate, quantity, and type are seldom as originally envisioned, it's good to look at the historical trends of the average rate of USAF tactical fighter production to determine if we are in fact now producing at a slower rate and thus less efficient. The common notion is that USAF airplanes used to come off the line like automobiles.

In this study production is defined as beginning with the delivery of the first operational aircraft and ending with the delivery of the last operational aircraft. In order to determine the average rate, the number of aircraft delivered to the USAF is divided by the number of months from first delivery to last delivery. The production people may take issue with this method, which ignores rate buildup and wind-down times. However, what is of interest here is not production capacities and delivery schedules as much as what would have been a smooth and efficient rate. Thus, action by Congress to keep lines open is included, low rate policies are included, etc. The results are then grouped into average rates per month as in Figure 7.

Some interesting features appear when production rates are arranged in this manner. The most obvious is that the predominant average rate of production has been and still is 10 to 20 aircraft per month. The extremely high rates of production of the F-86's and F-100's were possible because two separate production facilities were used simultaneously. Similarly the F-84's were produced at two facilities. The F-102 is the only real example

FIGURE 7
AVERAGE PRODUCTION RATE

(USAF TACTICAL FIGHTERS)

RATE PER MONTH				
0–10	10–20	20–30	30–40	40+
F-111 A-7 F-15	F-80 F-89 F-94 F-101 F-104 F-105 F-106 F-4 A-10 F-16	F-84 F-84F F-102	F-86 F-100	F-86D

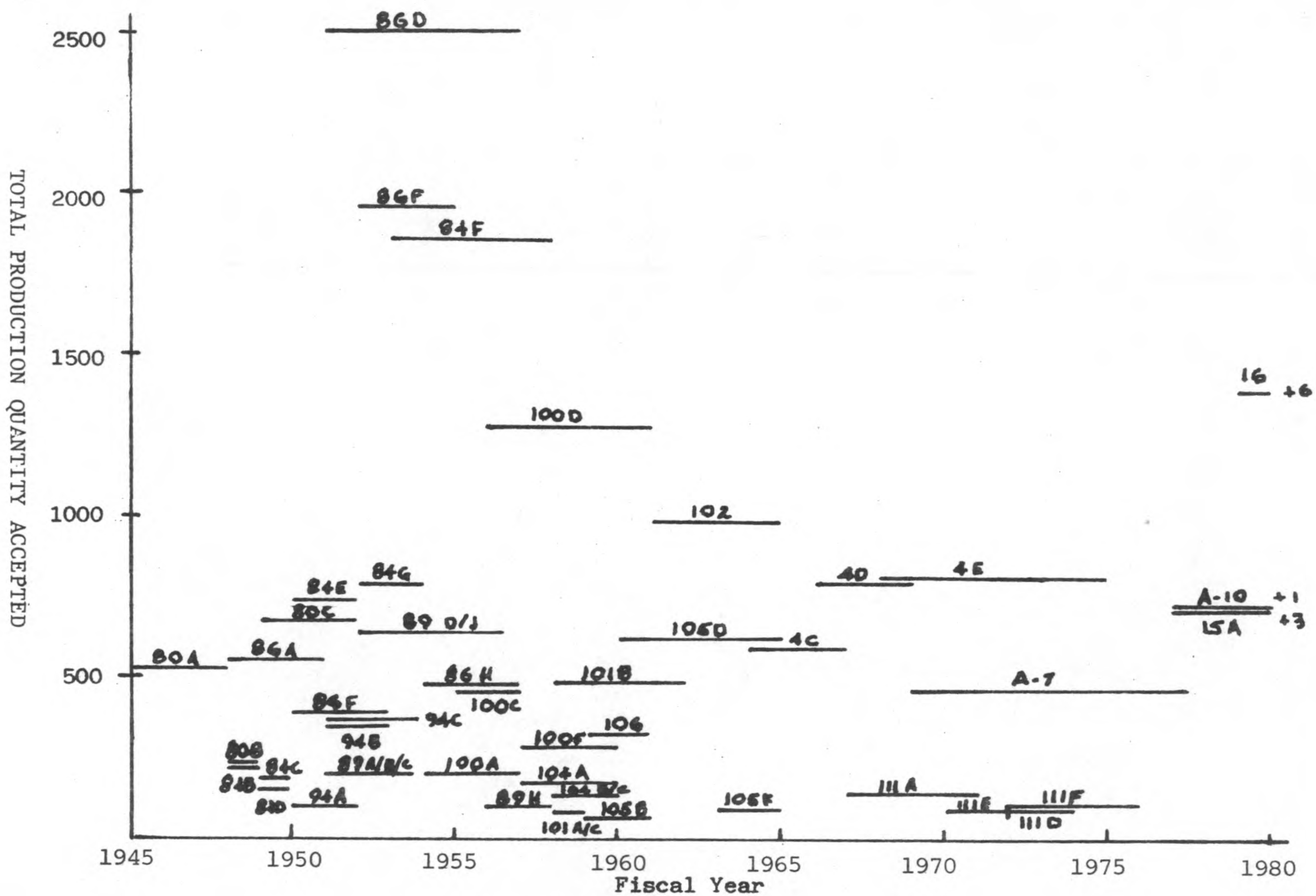
of higher than average rate at a single facility. It was also the product of the weapons system concept and Craig-Cook plan. There no doubt is some correlation, since the production line was set up and tested under this plan during full scale development. Overall, when all is said and done and the program is finished with production, the best guess is that the production will have averaged a rate of 10-20 aircraft per month.

The number of models or versions of each aircraft type as well as the number of types has decreased somewhat. In the early days of this period it was not uncommon to have four or more different models of each type. Often the early models were being phased out of the inventory while the later models were still being produced. With this rapid turnover of models came the inherent logistical problems. For instance there were three distinct F-86 models; the D's, the H's and the rest. About all that was common in these was the type number. Nowadays, the trend is toward fewer types, and models of each type, e.g., the A-7, F-16 and A-10. However, for the F-15 we now have the second model, a new one is proposed for the A-10, and a new engine is proposed for the F-16. Further, the announced policy of advancing existing airframes[15] will introduce more new models. It can be said, though, that such introductions will probably not be as frequent as in the past.

In this same vein, that is, the variety and quantity of production on a model for model basis, the Air Force is buying about the same quantities as it has since the introduction of jets. Excluding the 84F, which had a short operational life, and the 86D, an interim interceptor, there is no significant trend in the quantities of individual models of aircraft delivered, as shown in Figure 8. There was a large variety of models and types being accepted in the 50's, with the Air Force taking delivery of 10 different models of aircraft in 1952. Now the Air Force is down to three models, and it has been accepting about that number of models for the past 15 years.

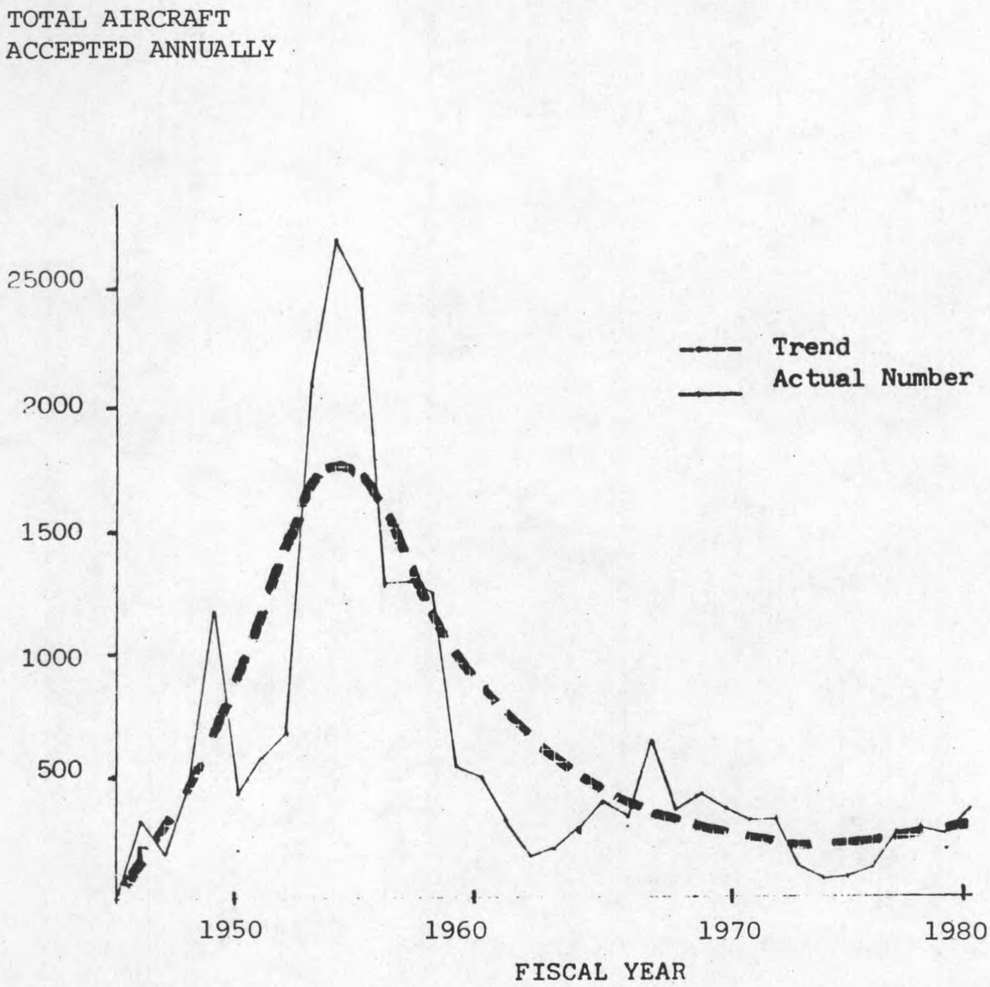
With the average production rates relatively constant and the number of aircraft produced per model in the same range, the dominant factor affecting the number of aircraft accepted annually is the number of models and types. (See Figure 9) The number of models and types presently being accepted is one per basic mission area and it appears that this number will not be exceeded for some time to come.

The industrial effect of the change in the nature of production is to reduce the number of facilities required to support the Air Force's annual production requirements. Projections indicate this will remain the case for some time, barring some unforseen crisis or technological breakthrough which would make the current models and types obsolete.



PRODUCTION RUN BY TYPE AND MODEL [16]

Figure 8



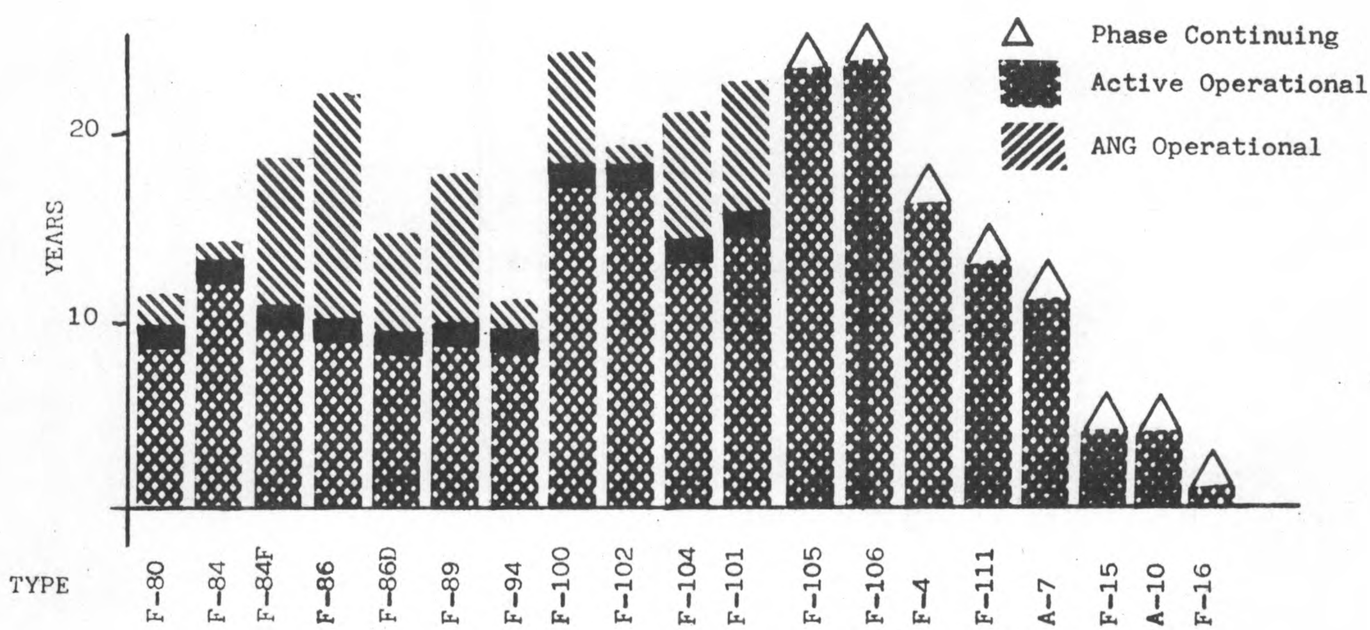
ANNUAL AIRCRAFT ACCEPTANCE
(Tactical Fighters - All Types)

Figure 9

IV. DEPLOYMENT

The deployment or operational time of aircraft systems must be considered when evaluating the life cycle of aircraft systems. In this study deployment is measured from the first delivery to an operational unit to the phase-out of active forces. Use of the systems by the Air National Guard has been noted and it is acknowledged that ANG deployment is increasingly important. However, since this study spans the period of modernization of the Air National Guard with current systems, their deployment has not been considered.

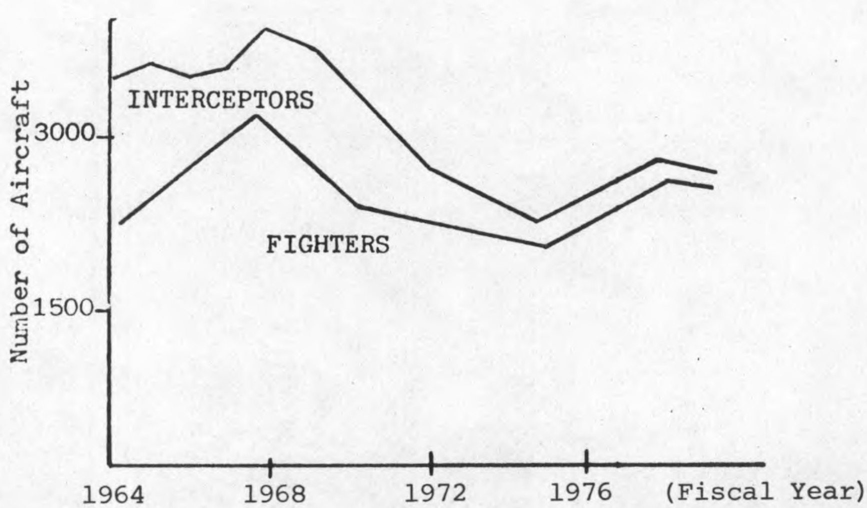
For the active forces there has been a major shift in the trend of the deployment life of aircraft systems. The mean lifetime has gone from an average of ten years in the 1950's to almost 20 years average for the first generation supersonic aircraft. Two of those systems, the F-105 and F-106, are still on active duty in late 1978. Further, not only has there been a shift in the deployment times of the fighter aircraft systems, there also has been a major shift in the tactical mission. In 1964 when the Air Force



OPERATIONAL LIFE BY TYPE[18]

Figure 10

had approximately 3500 fighter aircraft in the active inventory, that number included 40 squadrons or about 720 interceptors for strategic air defense. The remaining tactical fighter force was about 2800 aircraft. The tactical fighter and attack forces for 1979 are about 2650 fighters.[19] Thus the major reason for wild swings in the fighter inventory has been the emphasis/deemphasis on strategic air defense. The tactical force remained fairly stable except for the Vietnam peak, and the current generation of aircraft will probably stay active about as long as its predecessors, or about 20 years. There could be some technological breakthrough which would cut short these deployment times, but none appears near and no one is planning for one.



ACTIVE FIGHTER AIRCRAFT [20]

Figure 11

V. COST TRENDS

In Dr. Perry's statement to Congress,[21] he indicates that there has been a nine percent rate of growth per year in the cost of new fighter aircraft weapons systems over the last 30 year period. Other studies[22] have indicated a five percent rate of growth per year in the cost of weapon systems. The issue is not whether the growth is five percent or nine percent; either figure will do as an estimate for the increased cost of becoming more technically sophisticated. It is more important for planning purposes to have some notion of the increased cost of becoming more technically sophisticated as applied to specific services and as applied to specific mission areas. Therefore cost trends have been examined for Air Force tactical jet aircraft overall, air superiority aircraft, close air support aircraft and all weather interdiction (Figures 12 through 15).

For simplicity a few models of some types were not included because they had such short lives that they were not relevant or they duplicated information displayed by other models. The year indicated is the median fiscal year of production. The effect of using almost all models and their respective fly-away costs is to show the divergence in the costs of aircraft, model for model, for the same type. For instance, the cost of an F-105B is over twice that of the F-105D. Also, when examining specific mission areas, aircraft which have models in different mission areas can be more readily included in the sample.

Fly-away cost[23] has its shortcomings when used to measure the increased cost of technology. It is a readily available figure and acceptable in indicating trends. However, its shortcomings should be kept in mind. In addition to improved tactical capability, increasing fly-away costs result as the aircraft is made more self-reliant, more reliable, and more maintainable. For example, there are increased costs in the fly-away cost of an F-15 which are not directly comparable with other aircraft systems. The F-15 has a self-start capability. In comparison with an F-4, a full stabilator can be changed in one-third the time. The maintenance man-hours-per-flight-hour is one-third that of F-101.[24] These features all increase the fly-away cost of the current generation aircraft and are thought of as an increased cost of technology, hence capability, when in fact they are a tradeoff in the life cycle costs of the system. However, even with these shortcomings of the fly-away cost figures, a study of them is revealing and indicative of what's going on in the cost growth picture.

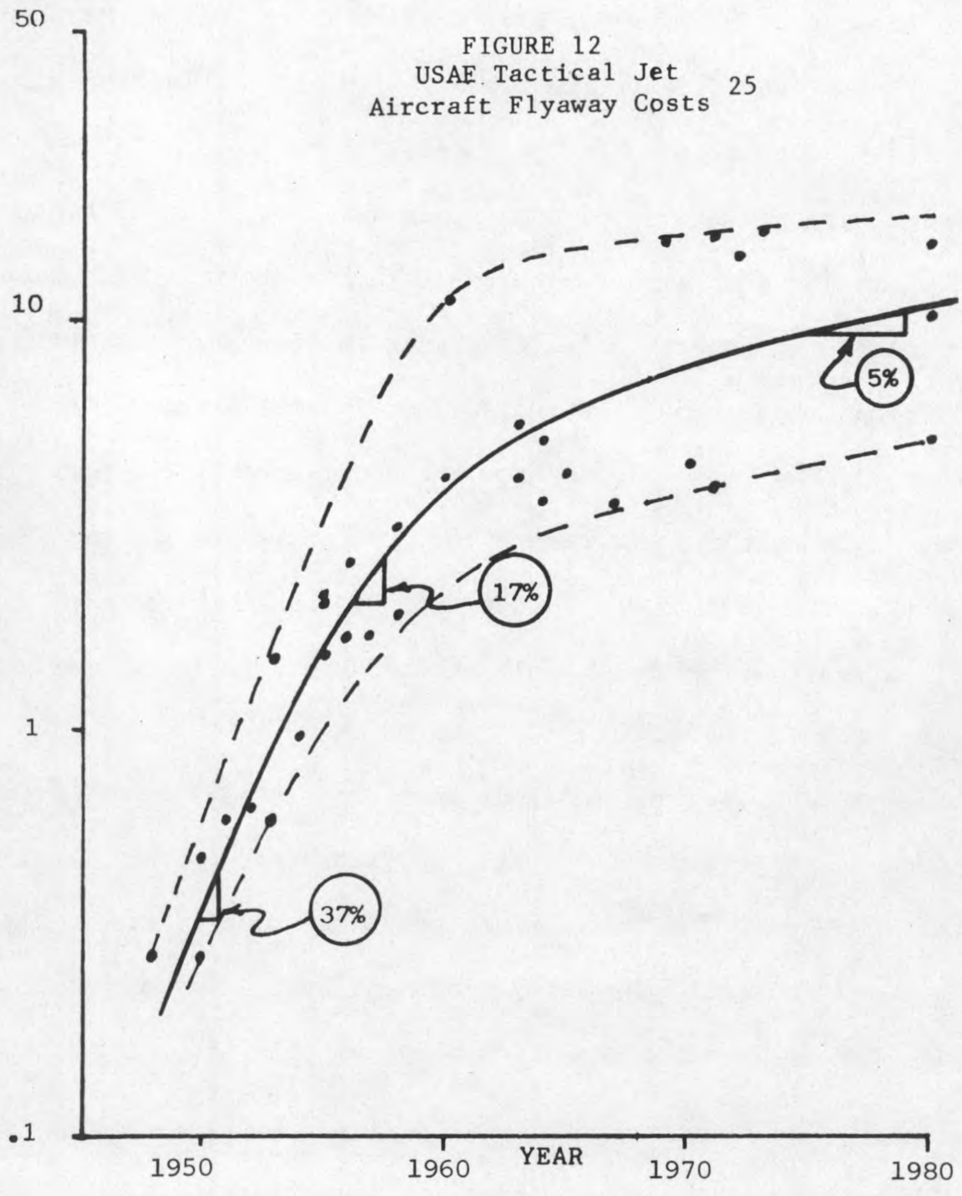


FIGURE 12
USAF Tactical Jet Aircraft Flyaway Costs [25]

From Figure 12 it can be seen that the current overall cost growth, in constant dollars, is somewhere in the five to ten percent range. It is important to note, however, that the rate of growth of the fly-away costs is less when compared to the first few generations of jet aircraft. It is also significant for historical purposes to note that the "knee" in the curve occurred coincidentally with the McNamara administration and initially was largely due to adapting Navy aircraft to Air Force missions. Rigorous cost ceilings on the F-15, F-16 and A-10 have continued this favorable trend. However this cumulative view obscures the cost growth of technology of separate mission areas.

In the air superiority mission area as defined as both all-weather and beyond visual range, the cost growth of technology on the whole is something less than that of the cumulative picture (Figure 13). However, there is a significant difference in the growth in the high and low of the high-low mix, with the low growing more rapidly. What such growth probably indicates is that more and more technology is being incorporated in the low technology solutions, such that the differential in capability between the high and low is becoming less. The high technology solutions should be relatively stable with small increments of cost growth, because the present state of the art has technical solutions for nearly the entire mission area. Further, agility and technical capability is being transferred from the aircraft to the missile systems. Therefore, the air superiority mission area should show a relatively small cost growth and be predictable and controllable.

In the close air support/attack mission area, the rate of cost growth of technology has been diminishing, also, with little differential between the high and the low of the high-low mix (Figure 14). This indicates a fairly close control of the technology and the capabilities of the aircraft systems. Although the early systems, the F-80, F-84, and F-100 were not specifically

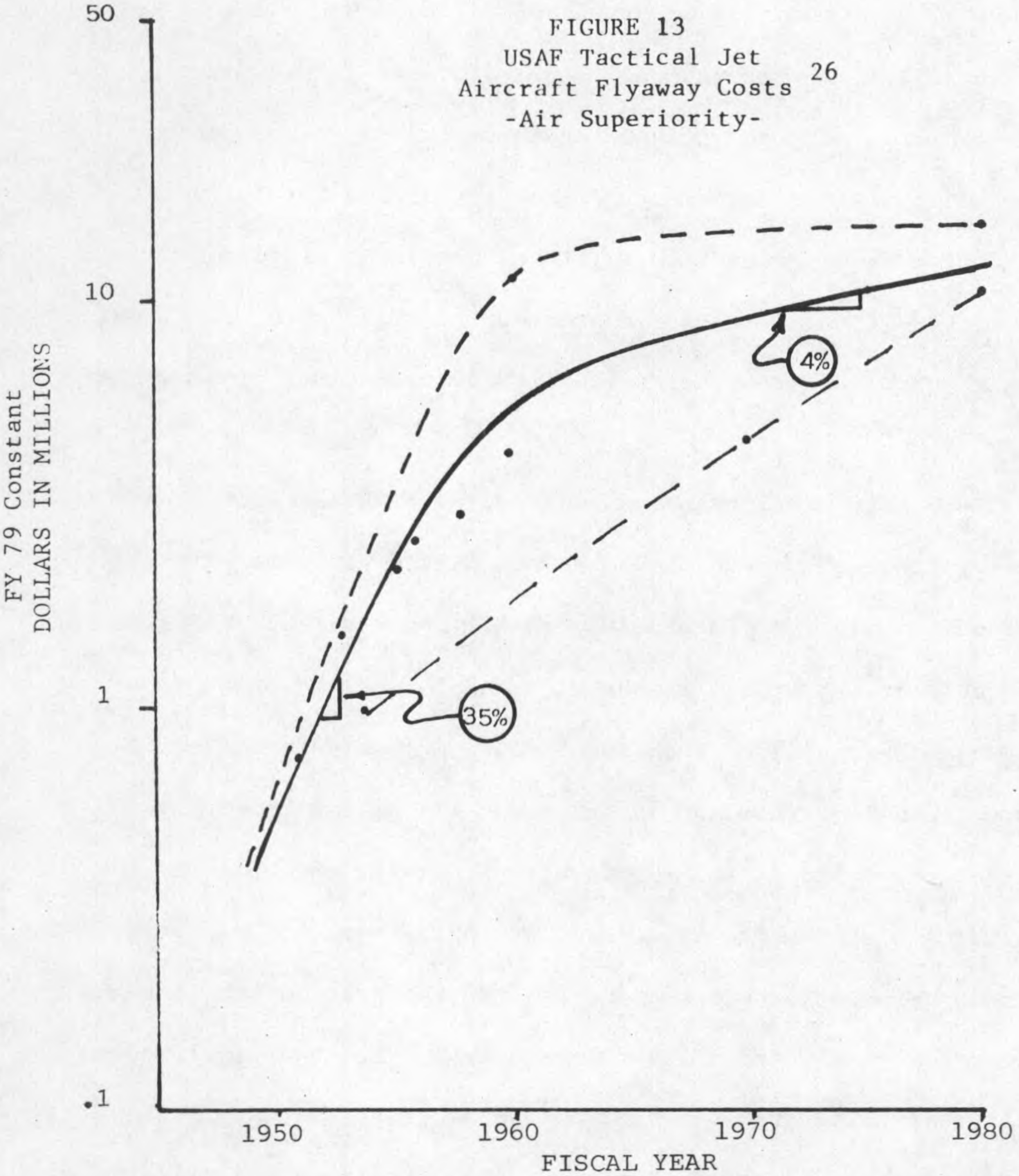
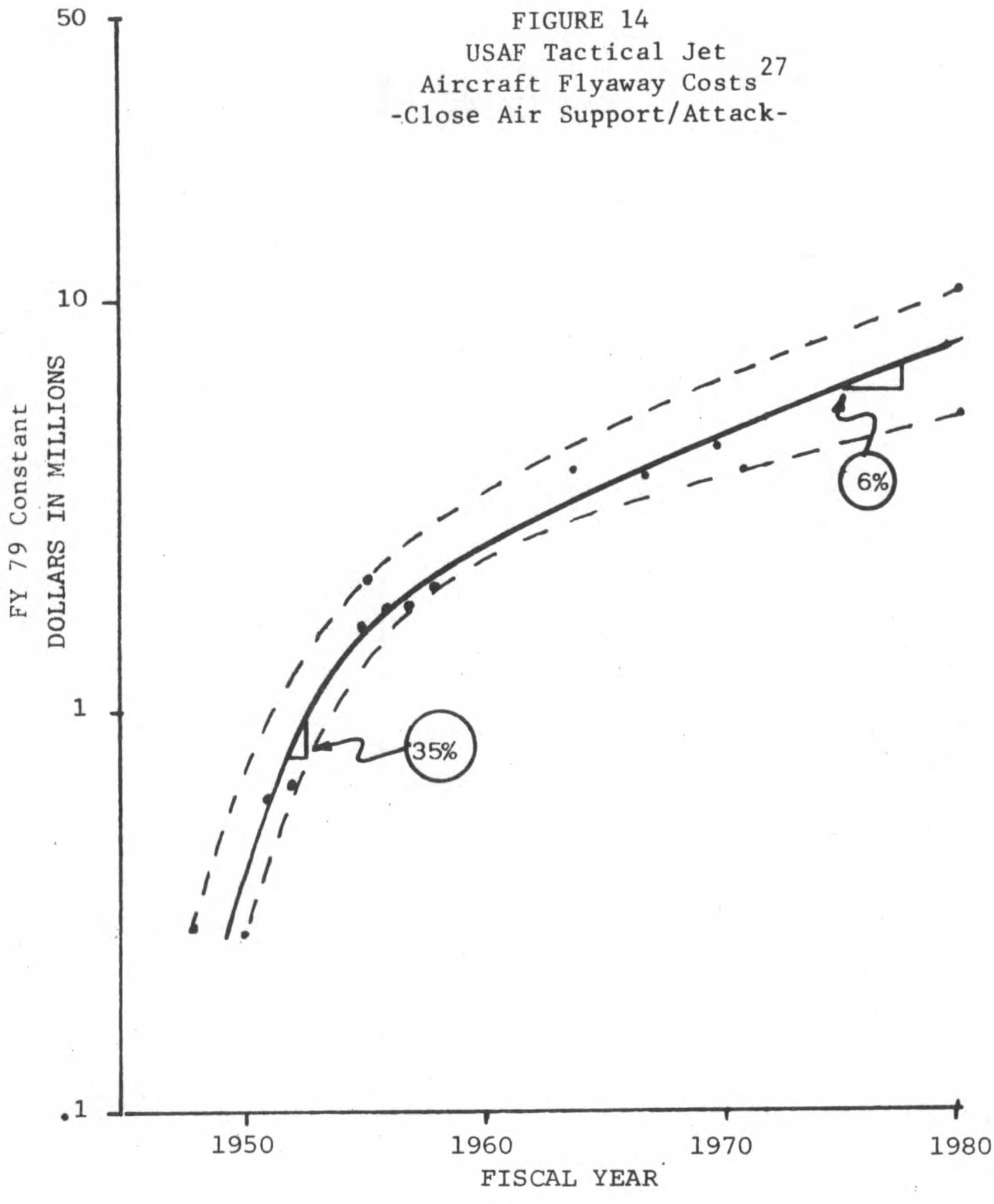
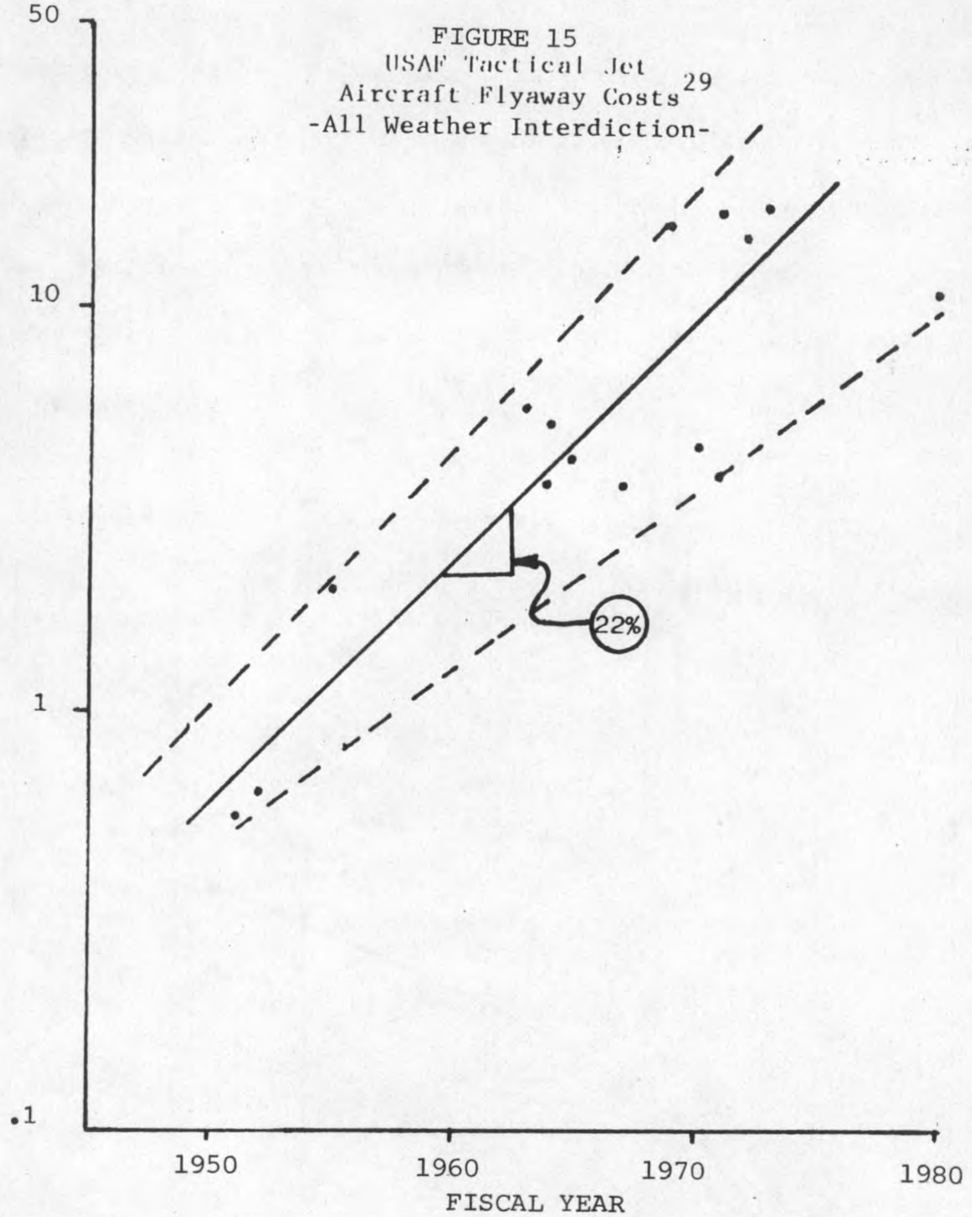


FIGURE 13
USAF Tactical Jet
Aircraft Flyaway Costs 26
-Air Superiority-
50
10
1
.1
FY 79 Constant
DOLLARS IN MILLIONS
4%
35%
1950
1960
1970
1980
FISCAL YEAR

designed for the close air support role, they were used in that role predominantly, so those systems are included to give some indication of the trends in technical cost growth. However, it can be seen that as an increasingly sophisticated all-weather capability is incorporated into aircraft of the close air support mission area, the growth rate of the cost of technology will increase rapidly.

FIGURE 14
USAF Tactical Jet
Aircraft Flyaway Costs[27]
-Close Air Support/Attack-





The all-weather interdiction area has the highest rate of growth in the cost of technology. There is a growth rate something on the order of 20 percent per year. This may seem astronomical; however, it is consistent with estimates for reconnaissance-strike all-weather aircraft.[28] The technological sophistication required for this mission area, plus the technical capabilities yet to be resolved, would indicate that the cost growth of technology will continue to increase at a rapid rate. Further, the cost growth of so-called austere systems is as much or more than all other mission areas. Therefore, it is in this area that the Air Force could easily price itself right out of the market if it doesn't carefully screen the requirements and the technological alternatives. If growth trends in this mission area cannot be slowed in follow-on systems, then alternative solutions and innovative approaches to the deep interdiction mission must be investigated. This area seems to be ripe for a repeat of the B-1 experience.

As can be seen from this discussion, the growth trends in the costs of aircraft are more significant in some mission areas than others. Careful management of the requirements and capabilities will affect the future growth trends. Tradeoffs of essential capabilities will have to be made in order for aircraft weapons systems to remain affordable, and those capabilities which are not included in aircraft systems must be resolved by alternative and hopefully less expensive weapons systems.

IV. CONCLUSIONS

There are several conclusions to be drawn from this study. However, the major one is that one should be very careful when speaking in absolutes and even cautious when speaking relatively. "Things are worse." Worse than when? There has been a shift in the nature of fighter aircraft development and life cycles. Understanding the changes and the circumstances surrounding those changes is essential to making assertions about the future trends based upon historical trends.

The development cycle is getting longer. At least, the time period called full scale development is growing. To say anything more would simply be the result of a bookkeeping exercise. It is not clear that there is a cause and effect, but longer development cycles seem to be associated with systems which have a longer deployment life. Recent systems are not as rapidly overwhelmed by technological innovation as in earlier years. As a matter of fact, the new systems seem better able to absorb new technology than the old systems.

Average production rates have not changed significantly. There have been production lines with spurts of high rate production, which everyone remembers. However, those spurts are offset by low rates such that the average rate of production then and now is roughly the same.

Cost trends are significant. Even more significant, the variance in trends depends upon the mission area. As the search for technical solutions proceeds, the costs of some mission areas can become prohibitive. In those mission areas, careful screening of the requirements is a must, and those capabilities deleted must be incorporated in other weapons systems or foregone completely.

By reviewing the trends in U.S. Air Force tactical fighter life cycles, planners, program managers and analysts can evaluate future weapons systems proposals. Such a review highlights those areas of great sensitivity as well as those myths which have been perpetuated. The more disciplined and rigorous analysts may wish to contribute to this study area by further in-depth examination. Others may wish to group the data herein to arrive at another set of conclusions. Such efforts are encouraged with the view that such trend information is helpful in identifying what the Air Force can realistically expect to achieve with its fighter forces of the future.

Footnotes

1. Department of Defense, Defense Science Board, Report of the Acquisition Cycle Task Force, (Washington: U.S. Government Printing Office, 12 March 1978), p. v.

2. Marcelle S. Knaack, Encyclopedia of U.S. Air Force Aircraft and Missile Systems, Vol. I, Post World War II Fighters, 1945-1973, (Washington: U.S. Government Printing Office, 1978), p. 161.

3. Department of Defense, Office of the Undersecretary of Defense for Research and Engineering, The FY 80 Program for Research, Development and Acquisition, Overview Statement, (Washington: U.S. Government Printing Office, 1979), p. 5.

4. Ibid, p. 6.

5. Ibid, p. 8.

6. Herbert Coleman, "Existing Airframe Advances Stressed," Aviation Week and Space Technology, March 12, 1979, p. 28.

7. Defense Science Board, op. cit., p.v.

8. Marcelle S. Knaack, op. cit., v.p.; John W.R. Taylor, Ed., Jane's All The World's Aircraft 77-78, (New York: Franklin Watts, 1977), v.p.; and personal notes of the author.

9. The data for these figures are based upon the data contained in the appendix. Various sources were used to include the Encyclopedia of U.S. Air Force Aircraft and Missile Systems, Jane's,the various reports of the Department of Defense and of the Aerospace Industries Association of America. A bibliography has been included for further reference.

10. DOD, USDR&E, FY 80 Program, pp. 6-8.

11. Ibid, p. 6.

12. See note 9.

13. See note 9.

14. See note 9.

15. Herbert Coleman, "Technology, Threat Shape New Fighter," Aviation Week and Space Technology, March 29, 1979, p. 123.

16. See note 9.

17. See note 9.

18. See note 9.

19. Department of the Air Force, USAF Summary, (Washington: U.S. Government Printing Office, February 1978), p. FOR 4.

20. Ibid.

21. DOD, USDR&E, FY 80 Program, p. 5.

22. Jacques S. Gansler, Diminishing Power - The Defense Industrial Base, (Unpublished book draft, 1978), p. 74.

23. Flyaway cost is defined as the cost of airframe, engine, electronics and armament, to include government furnished equipment, installed at the time of government acceptance from the manufacturer. It does not include allowance for research and development, spares, provisioning, training, support equipment and military construction. Procurement costs were used in lieu of flyaway costs when such data were not readily available.

24. "Maintenance Aspects of F-15 Aircraft," Product Support, (St. Louis: McDonnell Aircraft Co., April 1974), pp. 16-20.

25. See note 9.

26. See note 9.

27. See note 9.

28. Author's personal experience while working in the F-15 System Program Office.

29. See note 9.

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__________, "Air National Guard," Air Force Magazine, May 1978, p. 103.

__________, "Air National Guard," Air Force Magazine, May 1978, p. 110.

__________, "Maintenance Aspects of the F-15 Aircraft," Product Support Digest, McDonnell Aircraft Co., St. Louis, 4th Quarter 1974.

__________, "Military Balance," Air Force Magazine, December 1975, p. 49.

__________, "Military Balance," Air Force Magazine, December 1978, p. 67.

APPENDICES

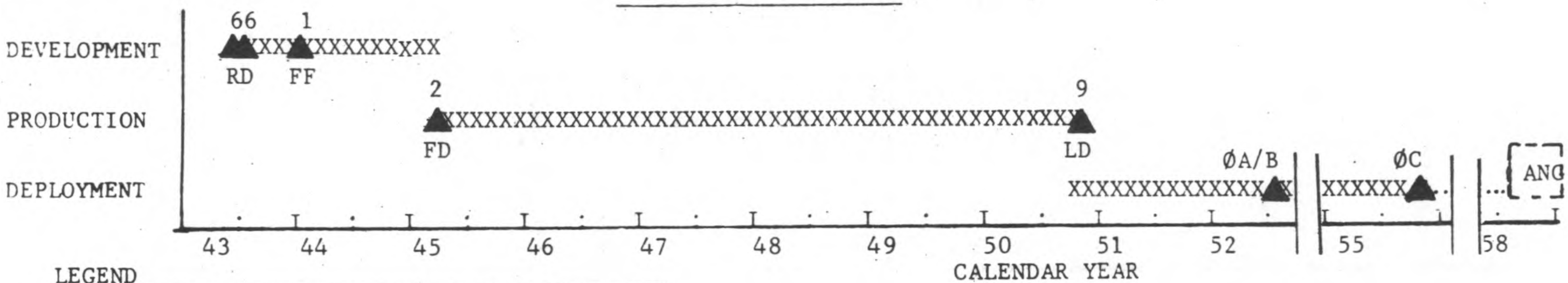
The data for the Appendices are from Marcelle S. Knaack, Encyclopedia of U.S. Air Force Aircraft and Missile Systems, Vol. I, (Washington, D.C.: U.S. GPO, 1978); John W.R. Taylor, ed., Jane's All The World's Aircraft, 77-78, (New York: Franklin Watts, 1977); Aerospace Industries Association of America, Inc., 1976/77 Aerospace Facts and Figures, (New York, McGraw Hill, 1977) and various reports of the U.S. Department of Defense.

APPENDIX I - Data for Individual Aircraft

Type: F-80

PROGRAM: F-80 MANUFACTURER: Lockheed PURPOSE: Day Fighter DERIVATION: None

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	45	46	47	48	49	50	51				TOTAL	FLY AWAY COST IN $
F-80A	33	311	181								525	95,000
F-80B				240							240	95,000
F-80C					670 ------→						670	93,400
RF-80A			152								152	107,800
											1587	

NOTES:

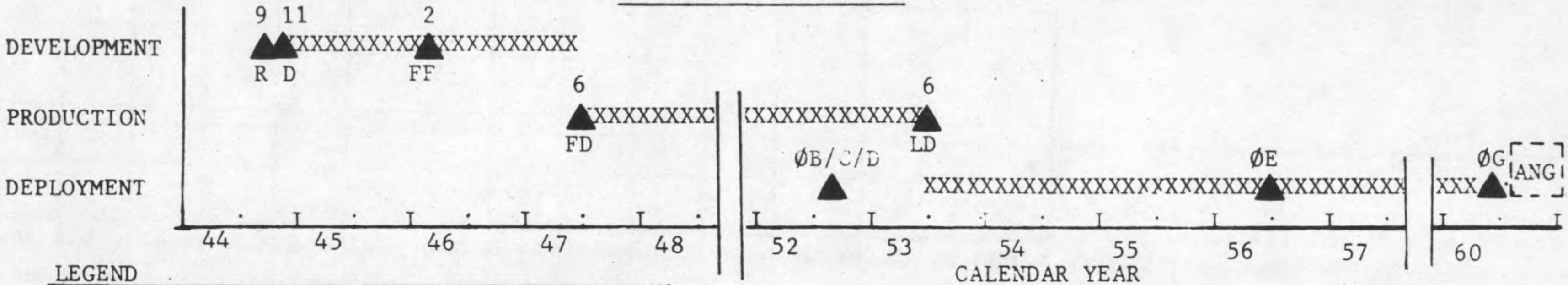
R & D COSTS: $15,000 average cost per aircraft

UNIQUE PROGRAM INITIATIVES:
-First production jet aircraft in the US.

FMS/MAP PRODUCTION: 100

PROGRAM: F-84 MANUFACTURER: Republic PURPOSE: Day Fighter DERIVATION: None

PROGRAM MILESTONES



LEGEND

R = Requirement FD = First Delivery
D = Development LD = Last Delivery
FF = First Flight Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	48	49	50	51	52	53					TOTAL	FLY AWAY COST IN $
F-84B	226										226	164,000
F-84C		191									191	148,000
F-84D		154									154	212,000
F-84E			350	393							743	212,000
F-84G					447	342					789	237,000
											2103	

NOTES:

R & D COSTS: In excess of $24 million.

UNIQUE PROGRAM INITIATIVES:
..First Fighter with nuclear capability

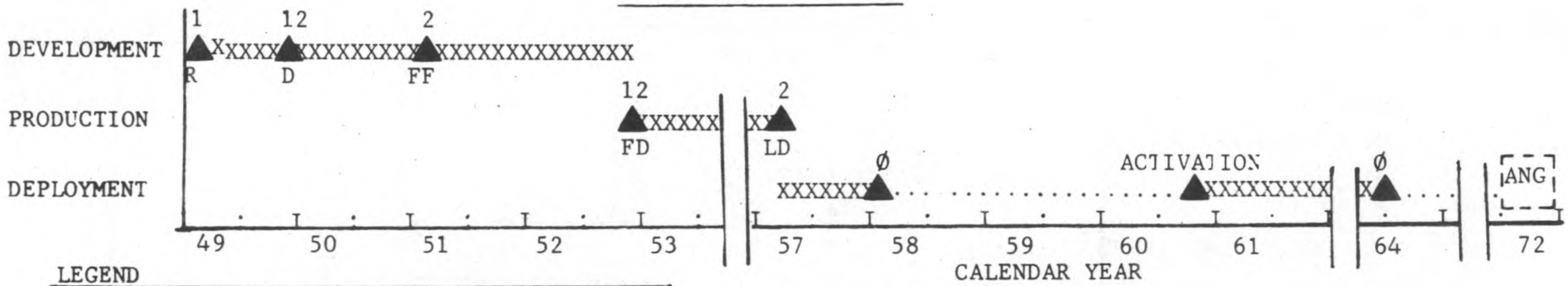
FMS/MAP PRODUCTION: 2336

Type: F-84

Type: F-84F

PROGRAM: F-84F MANUFACTURER: Republic/General Motors PURPOSE: Fighter Bomber DERIVATION: F-84G

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

NOTES:

R & D COSTS:

PRODUCTION QUANTITIES

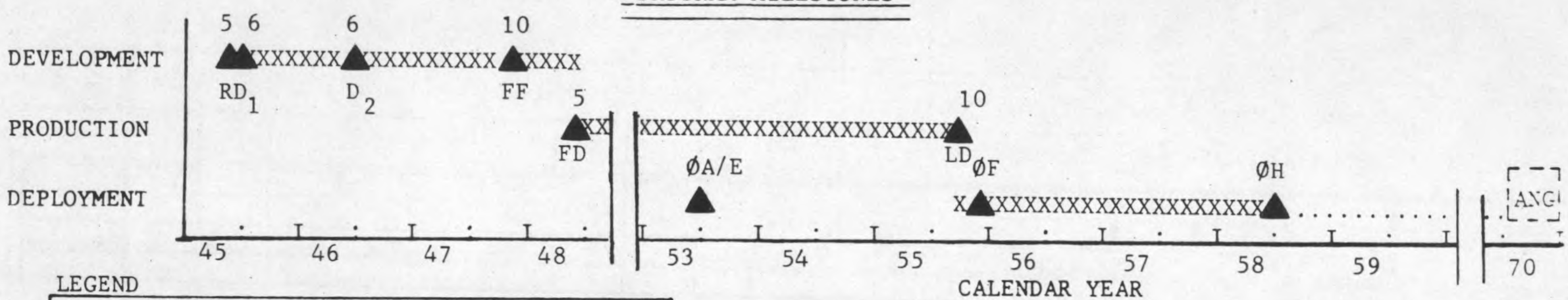
MODEL \ FY	53	54	55	56	57						TOTAL	FLY AWAY COST IN $
REP.	48	510	597	104							1259	769,000
GM	1	56	180								237	769,000
RF-84F		24	138	137	64						363	668,000
											1859	

UNIQUE PROGRAM INITIATIVES:
Tooling "55% common" with F-84E was actually 15% common.

FMS/MAP PRODUCTION: 1179

PROGRAM: F-86 MANUFACTURER: North American PURPOSE: Day Fighter DERIVATION: F1H

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	48	49	50	51	52	53	54	55	56		TOTAL	FLY AWAY COST IN $
F-86A	3	148	304	99							554	178,000
F-86E			80	218	98						396	219,000
F-86F					111	971	877				1959	211,000
F-86H							18	378	77		473	582,000
											3382	

NOTES:

R & D COSTS: $4,707,802 for three YF-86A's

UNIQUE PROGRAM INITIATIVES: F-86H used the "loose shoe" concept.

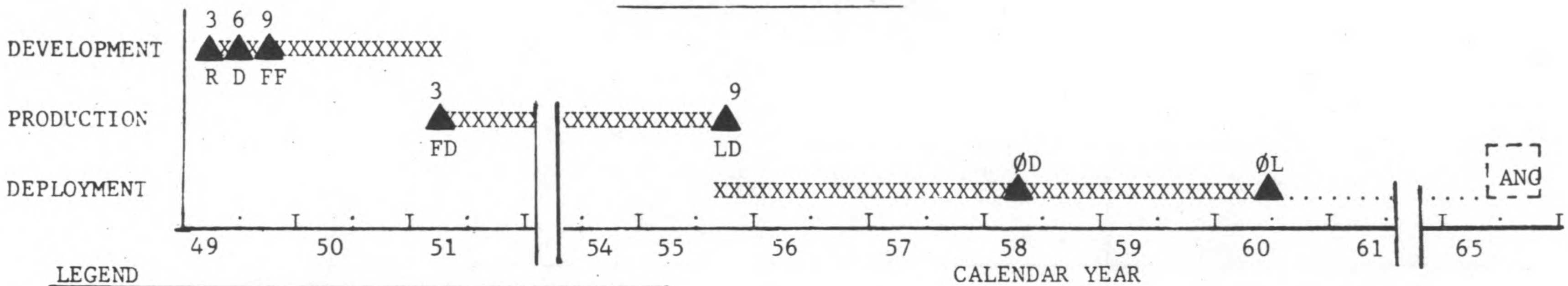
FMS/MAP PRODUCTION: 340

Type: F-86

Type: F-86D/L

PROGRAM: F-86D/L MANUFACTURER: North American PURPOSE: All Weather Interceptor DERIVATION: F 86

PROGRAM MILESTONES



LEGEND

R = Requirement
D = Development
FF = First Flight
FD = First Delivery
LD = Last Delivery
Ø = Phase out-model

NOTES:

R & D COSTS:
$7 Million to convert one F-86A

UNIQUE PROGRAM INITIATIVES:
Only the wing was common with the F-86.

FMS/MAP PRODUCTION: 120

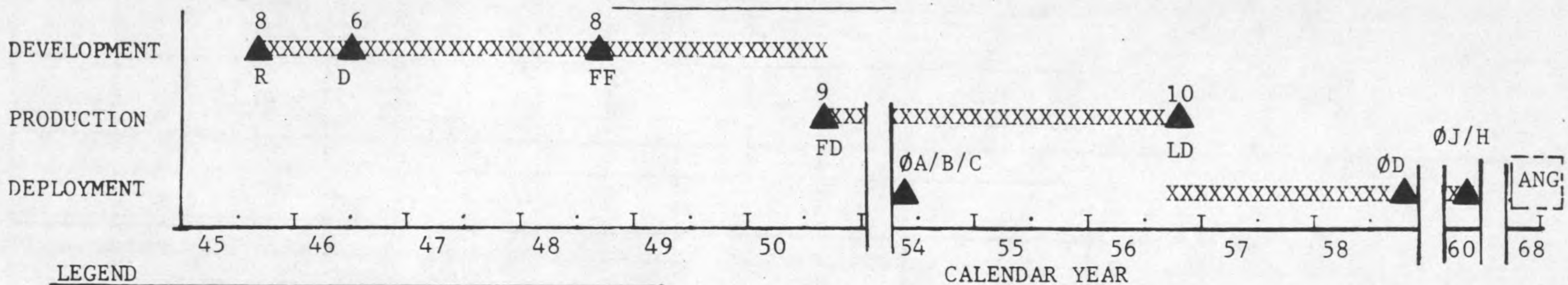
PRODUCTION QUANTITIES

MODEL \ FY	51	52	53	54	55	56					TOTAL	FLY AWAY COST IN $
F-86D	3	26	448	1014	860	153					2504	344,000
F-86L			(converted F-86D)								(620)	
											2504	

Type: F-89

PROGRAM: F-89 MANUFACTURER: Northrop PURPOSE: All Weather Interceptor DERIVATION: none

PROGRAM MILESTONES



LEGEND

R = Requirement FD = First Delivery
D = Development LD = Last Delivery
FF = First Flight Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	51	52	53	54	55	56	57			TOTAL	FLY AWAY COST IN $
F-89A	11									11	
F-89B	19	18								37	1,085,000
F-89C	48	128	53							163	797,000
F-89D		2	10	191	300	179				332	801,000
F-89J										350	1,000,000
F-89H						109	47			156	1,000,000
										1049	

NOTES:

R & D COSTS:
$5.6 million for two prototypes.

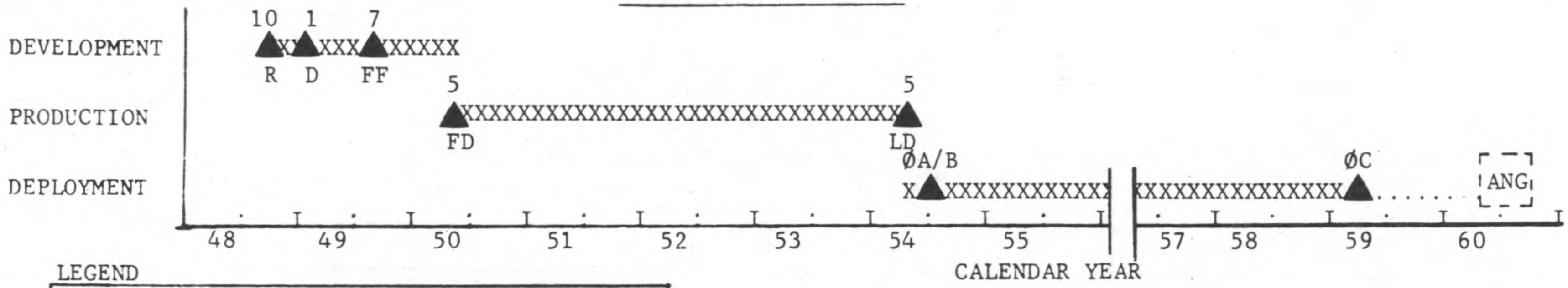
UNIQUE PROGRAM INITIATIVES:
First nuclear armed interceptor.

FMS/MAP PRODUCTION:

Type: F-94

PROGRAM: F-94 MANUFACTURER: Lockheed PURPOSE: All Weather Interceptor DERIVATION: F-80

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	50	51	52	53							TOTAL	FLY AWAY COST IN $
F-94A	14	95									109	258,000
F-94B		176	180								356	196,000
F-94C		9	153	225							387	534,000
											852	

NOTES:

R & D COSTS:

UNIQUE PROGRAM INITIATIVES:

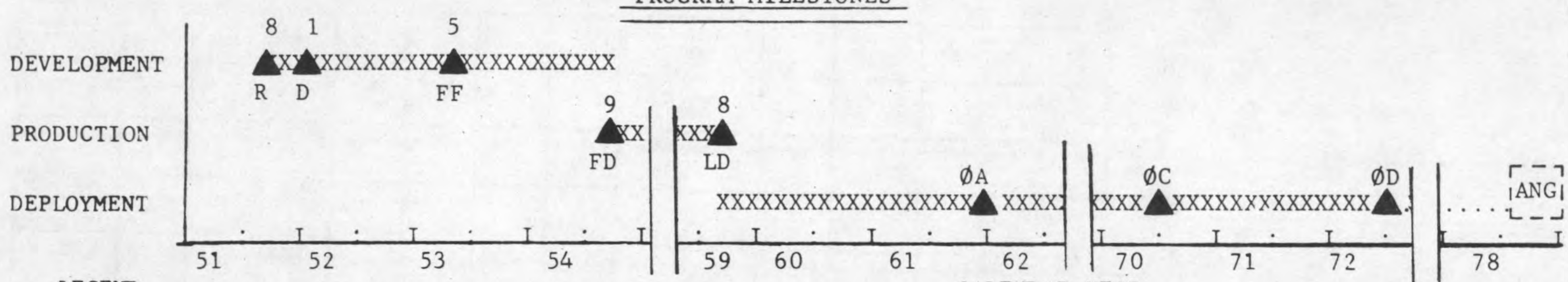
..interim imterceptor
..75% common with F-80C
.. First Afterburner

FMS/MAP PRODUCTION:

Type: F-100

PROGRAM: F-100 MANUFACTURER: North American PURPOSE: Day Fighter DERIVATION: none

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

NOTES:

R & D COSTS: $23.2 million

UNIQUE PROGRAM INITIATIVES:

..Unsolicited proposal.
..Derived from new interceptor program.

FMS/MAP PRODUCTION: 45

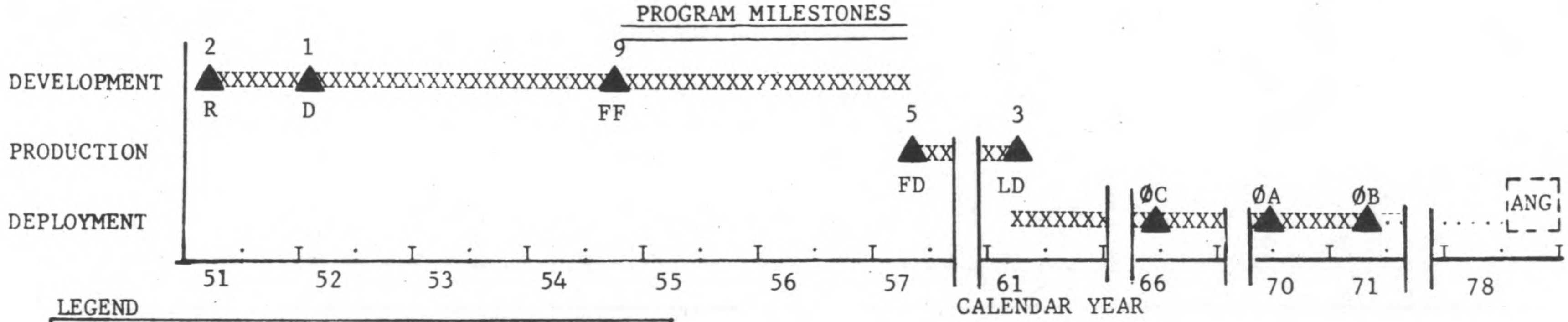
PRODUCTION QUANTITIES

FY / MODEL	54	55	56	57	58	59	60				TOTAL	FLY AWAY COST IN $
F-100A	15	165	23								203	1,015,000
F-100C		16	459	1							476	663,000
F-100D			* 113/2	576/212	166/120	75	10				1274	697,000
F-100F				14	227	53					294	804,000
											2247	

* Inglewood Plant/Columbus Plant

Type: F-101

PROGRAM: F-101 MANUFACTURER: McDonnell PURPOSE: Long Range Fighter Interceptor DERIVATION: XF-88



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

NOTES:

R & D COSTS: $13,333 per aircraft.

UNIQUE PROGRAM INITIATIVES:
- Fly before Buy policy (1954)
- **Craig Cook** low rate initial production policy (1951)

FMS/MAP PRODUCTION:

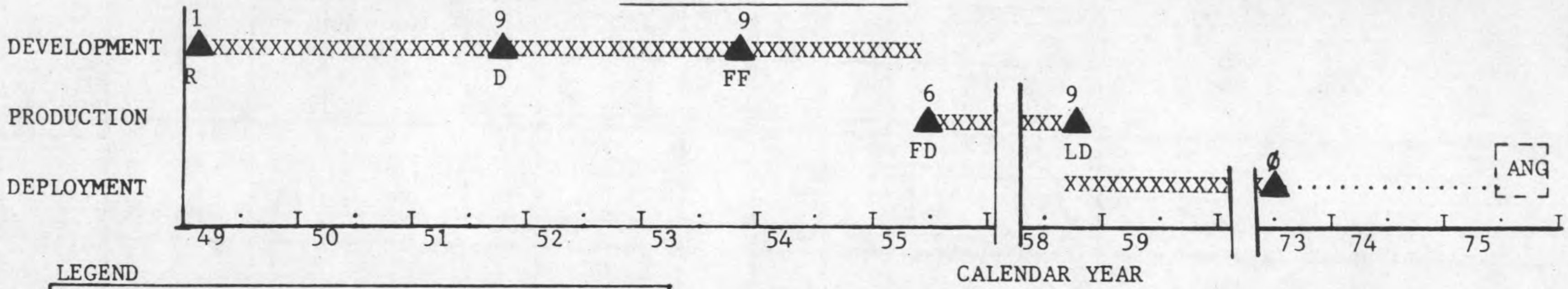
PRODUCTION QUANTITIES

FY / MODEL	57	58	59	60	61						TOTAL	FLY AWAY COST IN $
F-101A	2	35									37	2,906,000
F-101B	1	15	133	241	90						480	1,754,000
F-101C		47									47	1,276,000
RF-101A	20	15									35	1,605,000
RF-101C		80	86								166	1,276,000
RF-101G/H	(Modified RF-101A and RF-101C)											2,980,000
											765	

Type: F-102

PROGRAM: F-102 MANUFACTURER: Convair PURPOSE: Interceptor DERIVATION: XF-92

PROGRAM MILESTONES



LEGEND

R = Requirement FD = First Delivery
D = Development LD = Last Delivery
FF = First Flight Ø = Phase out-model

PRODUCTION QUANTITIES

FY / MODEL	55	56	57	58	59						TOTAL	FLY AWAY COST IN $
F-102A	1	45	372	427	30						875	1,200,000
TF-102		3	27	76	5						111	1,500,000
											986	

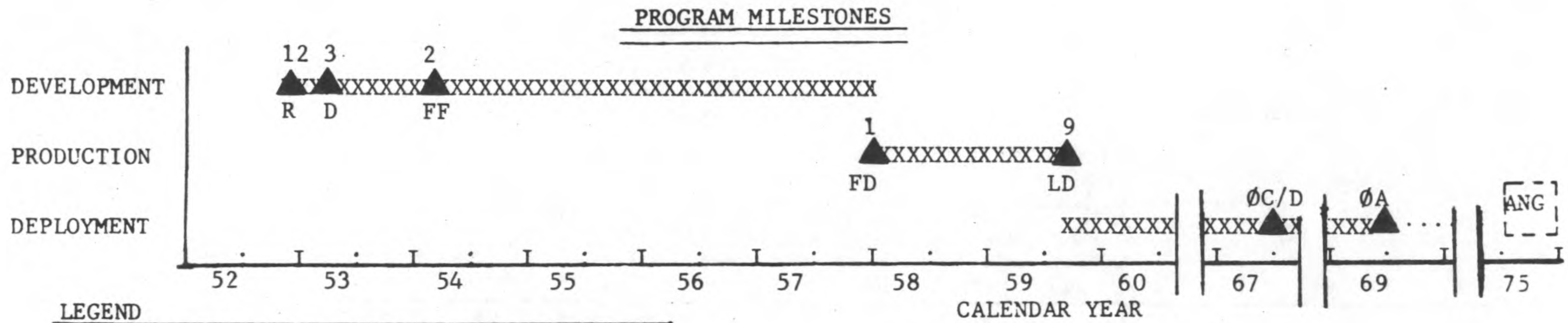
NOTES:

R & D COSTS: $101.92 million

UNIQUE PROGRAM INITIATIVES:
..Weapons System Development Concept (1949)
..Craig Cook LRIP (1951)
..First step in a two-step development program.

FMS/MAP PRODUCTION:

PROGRAM: F-104 MANUFACTURER: Lockheed PURPOSE: Fighter Bomber Interceptor DERIVATION: X-3



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

NOTES:

R & D COSTS: $189,000 per aircraft.

UNIQUE PROGRAM INITIATIVES:
..Unsolicited proposal
..Attempt to reverse growth/cost trend.
..Origional effort conducted under the new interceptor program.

FMS/MAP PRODUCTION: 1400

PRODUCTION QUANTITIES

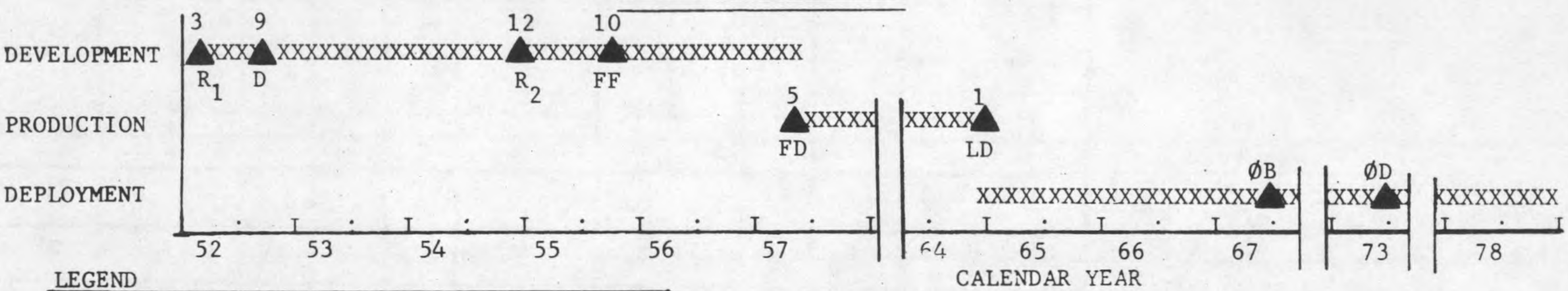
MODEL \ FY	56	57	58	59	60						TOTAL	FLY AWAY COST IN $
F-104A	7	28	94	41							170	1,700,000
F-104B		1	14	11							26	2,400,000
F-104C				77							77	1,500,000
F-104D				16	5						21	1,500,000
											294	

Type: F-104

Type: F-105

PROGRAM: F-105 MANUFACTURER: Republic PURPOSE: Fighter Bomber DERIVATION: None

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	57	58	59	60	61	62	63	64	65		TOTAL	FLY AWAY COST IN $
F-105B	3	6	28	38							75	5,649,000
F-105D				17	149	171	198	75			610	2,400,000
F-105F							1	83	59		95	2,200,000
F-105G			(Modified F-105F)								48	
											828	

NOTES:

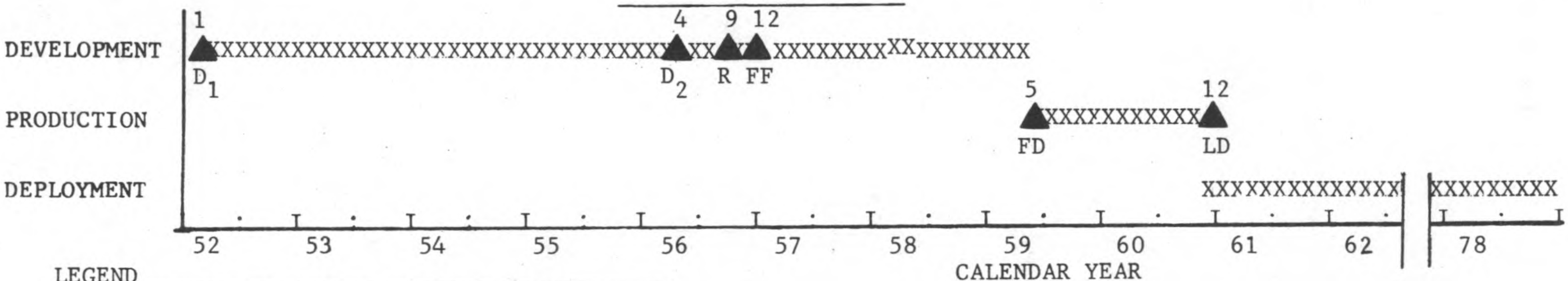
R & D COSTS:

UNIQUE PROGRAM INITIATIVES:
Company developed Aircraft.

FMS/MAP PRODUCTION:

PROGRAM: F-106 MANUFACTURER: Convair PURPOSE: All weather Interceptor DERIVATION: F-102

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

FY / MODEL	57	58	59	60	61						TOTAL	FLY AWAY COST IN $
F-106A	2	16	45	150	62						275	4,700,000
F-106B		1	11	36	15						63	4,900,000
											338	

NOTES:

R & D COSTS: $1.0 million
..35 test aircraft converted to operational status.

UNIQUE PROGRAM INITIATIVES:
..Second step in the two step development.
..Majority of the development done in F-102 program

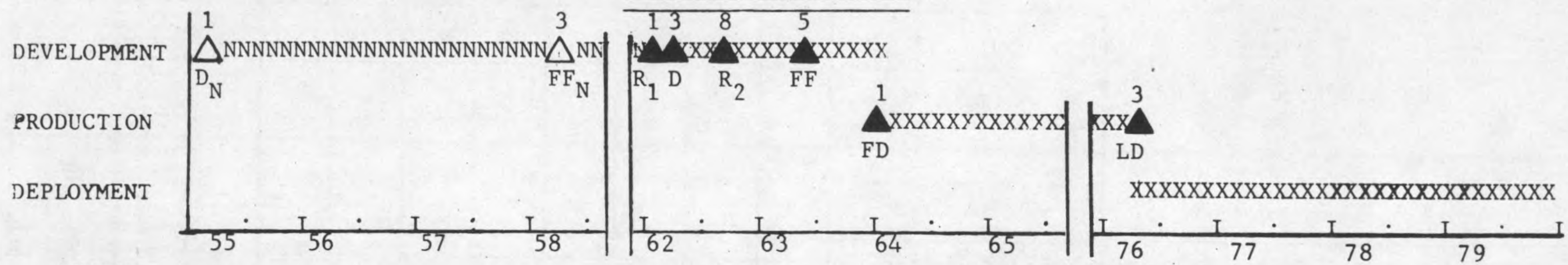
FMS/MAP PRODUCTION:

Type: F-106

Type: F-4

PROGRAM: F-4 MANUFACTURER: McDonnell Douglas PURPOSE: Fighter DERIVATION: Navy F4H-1

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	63	64	65	66	67	68	69	70	71	72*	TOTAL	FLY AWAY COST IN $
F-4C	1	128	280	174							583	1,900,000
F-4D				68	519	206					739	1,700,000
F-4E					1	145	242	186	105	133	812	2,400,000
RF-4C		4	56	124	110	68	58	17	18		499	2,300,000
											2687	

*programed through FY 74.

NOTES:

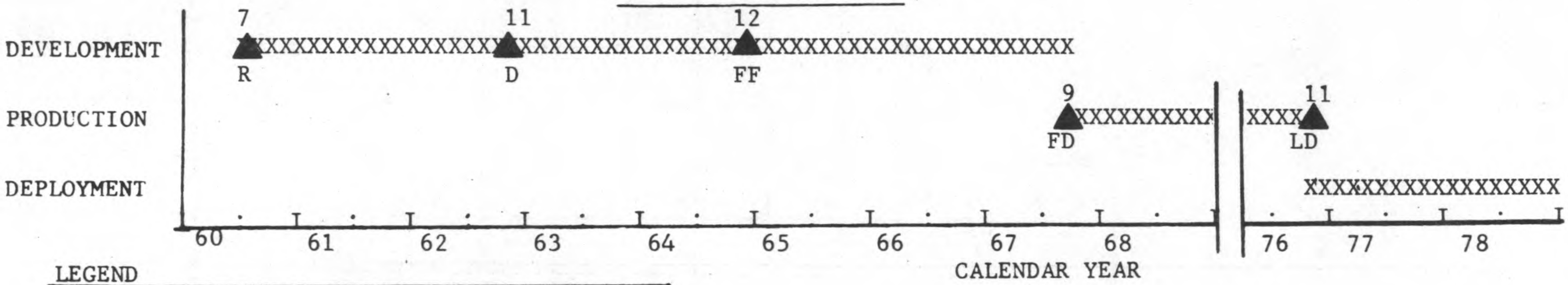
R & D COSTS: $22,700 per aircraft for the F 4E.
..$61,200 per aircraft for the RF 4C.

UNIQUE PROGRAM INITIATIVES:
..Aircraft standardization program
..Merged AF/Navy logistic service.

FMS/MAP PRODUCTION:

PROGRAM: F-111 MANUFACTURER: General Dynamics PURPOSE: Fighter Bomber DERIVATION: X-5

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	67	68	69	70	71	72	73	74	75	76	TOTAL	FLY AWAY COST IN $
F-111A	5	36	86	14							141	8,200,000
F-111D				1		28	67				96	8,500,000
F-111E				31	63						94	9,200,000
F-111F						70	6	12	6	6	106	10,300,000
FB-111			3	6	66						75	9,800,000
											512	

NOTES:

R & D COSTS: $1.657 billion

UNIQUE PROGRAM INITIATIVES:
..Correction of deficiencies

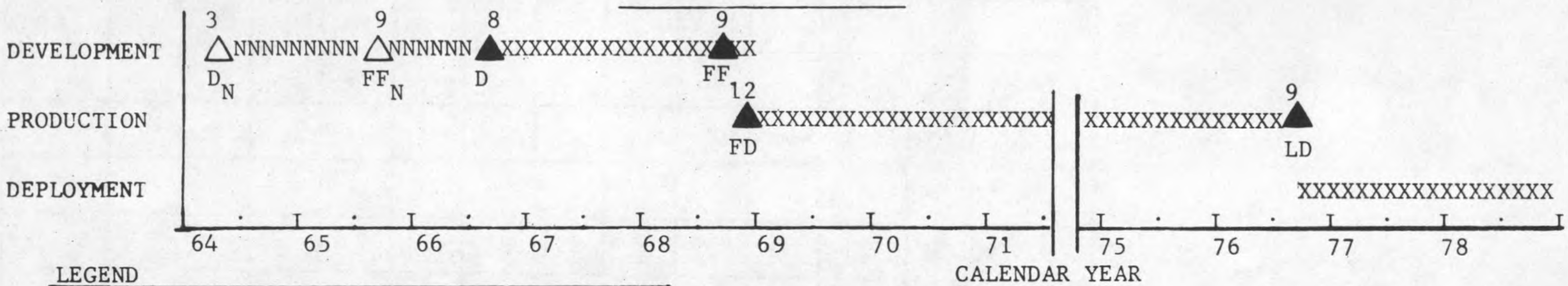
FMS/MAP PRODUCTION: 24

Type: F 111

Type: A-7

PROGRAM: A-7 MANUFACTURER: Vought PURPOSE: All Weather Attack DERIVATION: Navy F-8

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

PRODUCTION QUANTITIES

MODEL \ FY	69	70	71	72	73	74	75	76			TOTAL	FLY AWAY COST IN $
A-7D	←				459			→			459	3,800,000*
											459	

* estimated

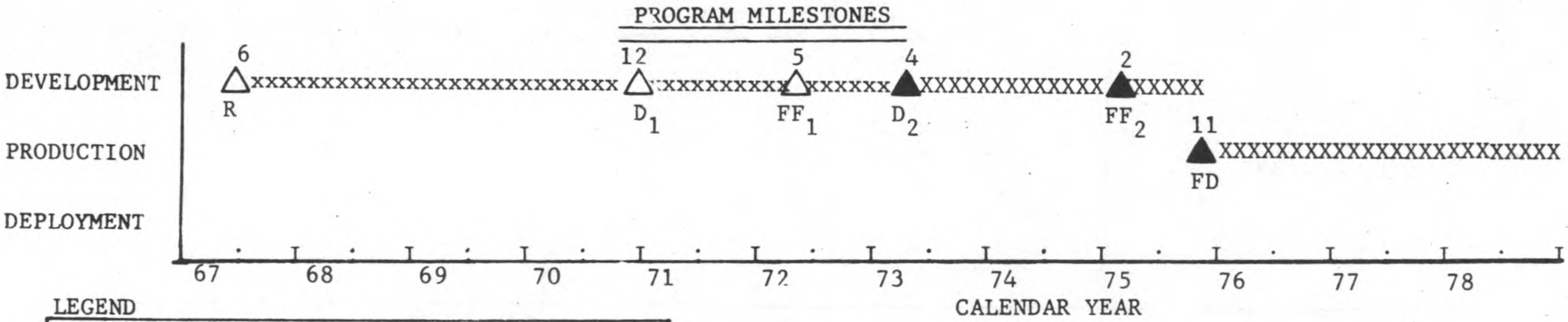
NOTES:

R & D COSTS:

UNIQUE PROGRAM INITIATIVES:

FMS/MAP PRODUCTION: 65

PROGRAM: A-10 MANUFACTURER: Fairchild Republic PURPOSE: Attack DERIVATION: none



LEGEND

R = Requirement FD = First Delivery
D = Development LD = Last Delivery
FF = First Flight Ø = Phase out-model

NOTES:

R & D COSTS: $447.5 million

UNIQUE PROGRAM INITIATIVES:
Prototype program

FMS/MAP PRODUCTION:

PRODUCTION QUANTITIES

FY / MODEL	77	78	79	80	81						TOTAL	FLY AWAY COST IN $
A-10	144	195	162	144	88						733	5,760,000*
											733	

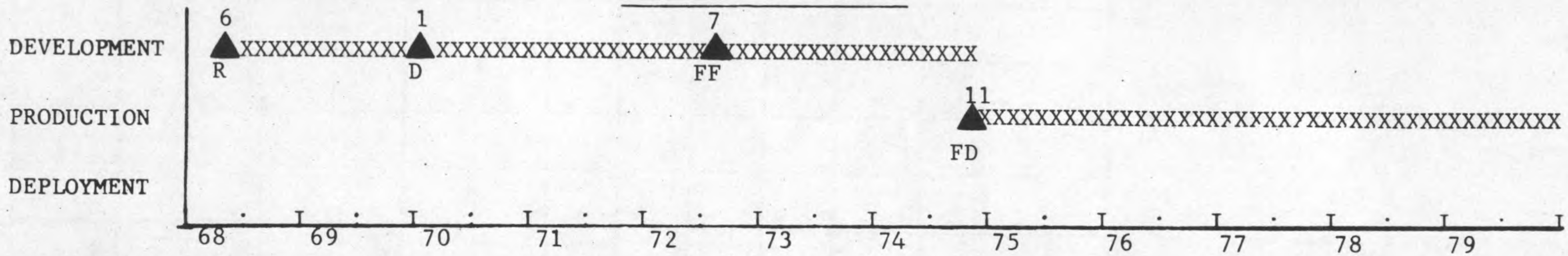
*procurement cost

Type: A-10

Type: F-15

PROGRAM: F-15 MANUFACTURER: McDonnell Douglas PURPOSE: All Weather Interceptor DERIVATION: none

PROGRAM MILESTONES



LEGEND

R = Requirement FD = First Delivery
D = Development LD = Last Delivery
FF = First Flight Ø = Phase out-model

NOTES:

R & D COSTS: $2.104 billion

UNIQUE PROGRAM INITIATIVES:
Blue line reporting

FMS/MAP PRODUCTION: 108

PRODUCTION QUANTITIES

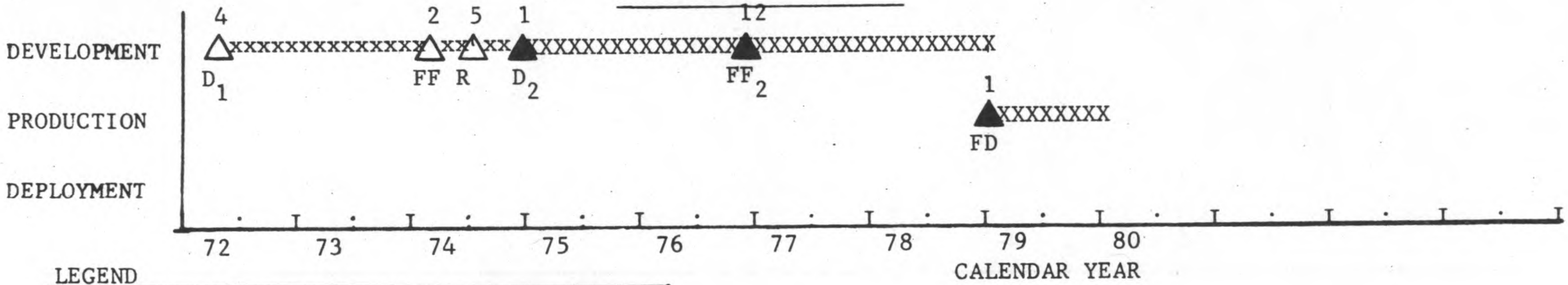
MODEL \ FY	75	76	77	78	79	80	81				TOTAL	FLY AWAY COST IN $
F-15A/B	25	80	119	96	64						384	15,220,000*
F-15C/D					33	63	249	--->			345	
											729	

* Procurement Cost

Type: F-16

PROGRAM: F-16 MANUFACTURER: General Dynamics PURPOSE: Fighter / Fighter Bomber DERIVATION: none

PROGRAM MILESTONES



LEGEND

R = Requirement	FD = First Delivery
D = Development	LD = Last Delivery
FF = First Flight	Ø = Phase out-model

NOTES:

R & D COSTS: $958.3 million

UNIQUE PROGRAM INITIATIVES:
..Prototype program
..International program

FMS/MAP PRODUCTION:

PRODUCTION QUANTITIES

MODEL \ FY	79	80	81	82	83						TOTAL	FLY AWAY COST IN $
F-16	105	145	175	963 ----------→							1388	10,140,000*
											1388	

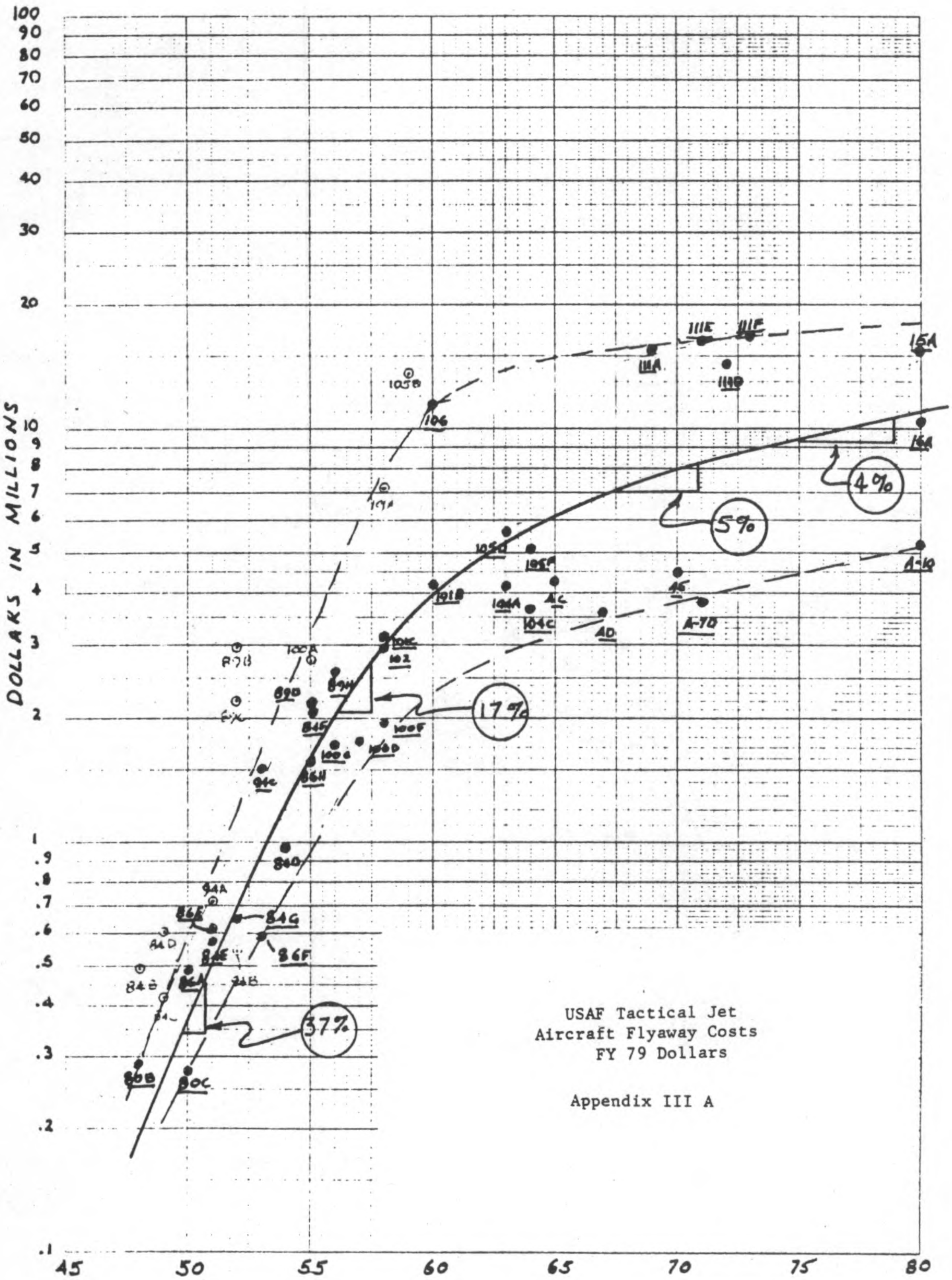
*Procurement Cost

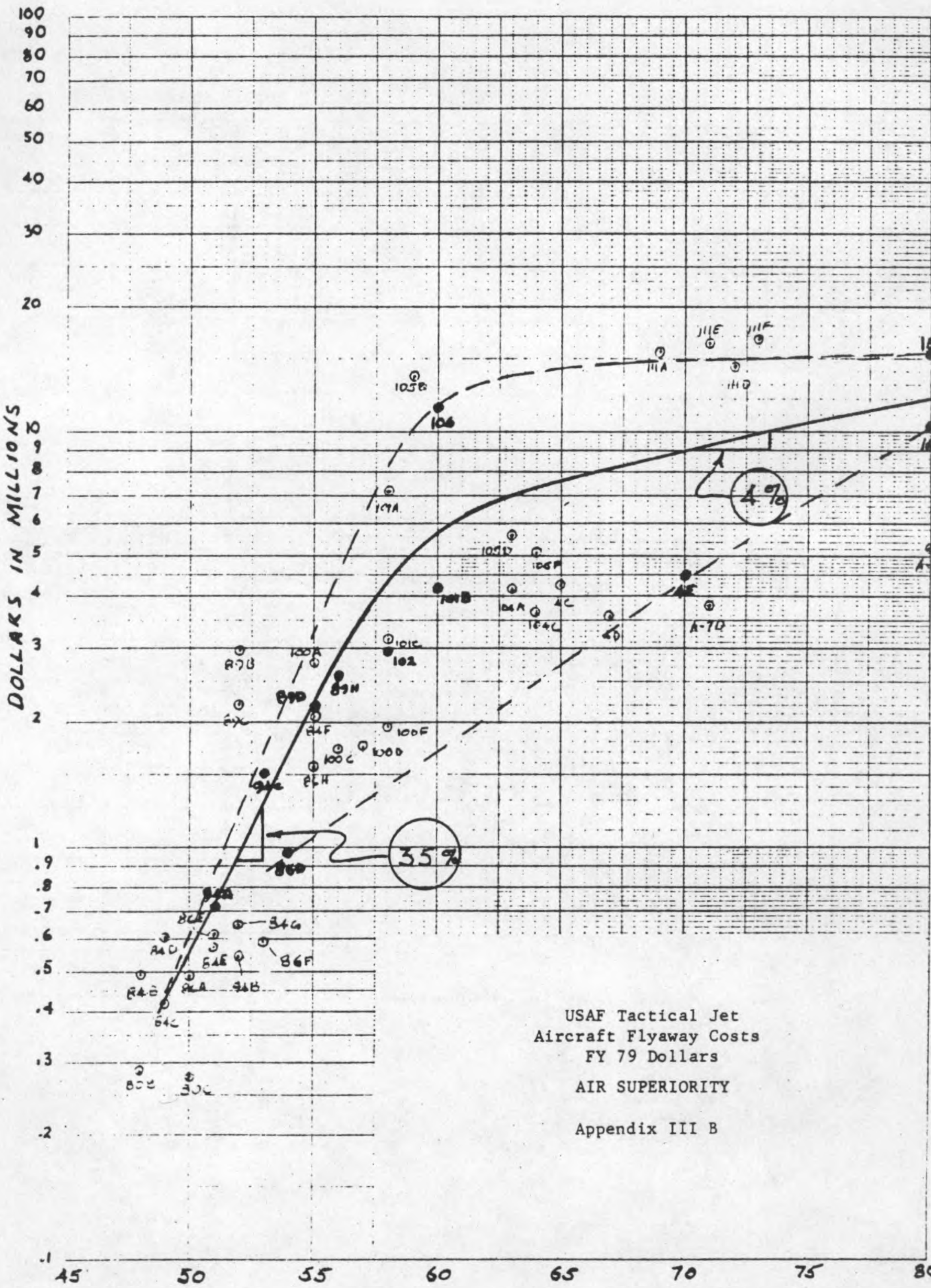
APPENDIX II - Flyaway Costs in Constant Dollars

Aircraft Fly Away Costs

Type/Model	Median Year	Then Year $ (000)	Indices	'79 Constant $ Price
F-80				
B	1948	95	32.9	288
C	1950	93	33.5	278
F-84				
B	1948	164	32.9	498
C	1949	148	35.2	420
D	1949	212	35.2	602
E	1951	212	36.4	582
G	1952	237	36.2	654
F	1955	769	37.0	2,078
F-86				
A	1950	178	36.4	487
E	1951	219	36.2	605
F	1953	211	35.4	596
H	1955	582	37.0	1,573
D	1954	344	35.5	969
F-89				
B	1952	1,085	36.2	2,997
C	1952	797	36.2	2,202
D	1955	801	37.0	2,164
H	1956	1,000	38.6	2,591
F-94				
A	1951	258	36.4	708
B	1952	176	36.2	541
C	1953	534	35.4	1,508
F-100				
A	1955	1,015	37.0	2,743
C	1956	663	38.6	1,718
D	1957	697	40.7	1,712
F	1958	804	41.0	1,961
F-101				
A	1958	2,906	41.0	7,087
B	1960	1,754	41.8	4,196
C	1958	1,276	41.0	3,112
F-102	1958	1,200	41.0	2,927
F-104				
A	1958	1,700	41.0	4,146
C	1959	1,500	41.3	3,632
F-105				
B	1959	5,649	41.3	13,678
D	1963	2,400	42.8	5,607
F	1964	2,200	43.9	5,011
F-106	1960	4,700	41.8	11,244
F-4				
C	1965	1,900	44.6	4,260
D	1967	1,700	47.7	3,564
E	1970	2,400	53.6	4,478
F-111				
A	1969	8,200	51.3	15,984
D	1972	8,500	58.7	14,480
E	1971	9,200	56.3	16,341
F	1973	10,300	61.2	16,830
A-7D	1971	3,800	56.3	6,750
A-10	1980	5,700	94.2	6,051
F-15	1980	15,200	-	15,200
F-16	1980	10,140	-	10,140

APPENDIX III - Trends in Flyaway Costs

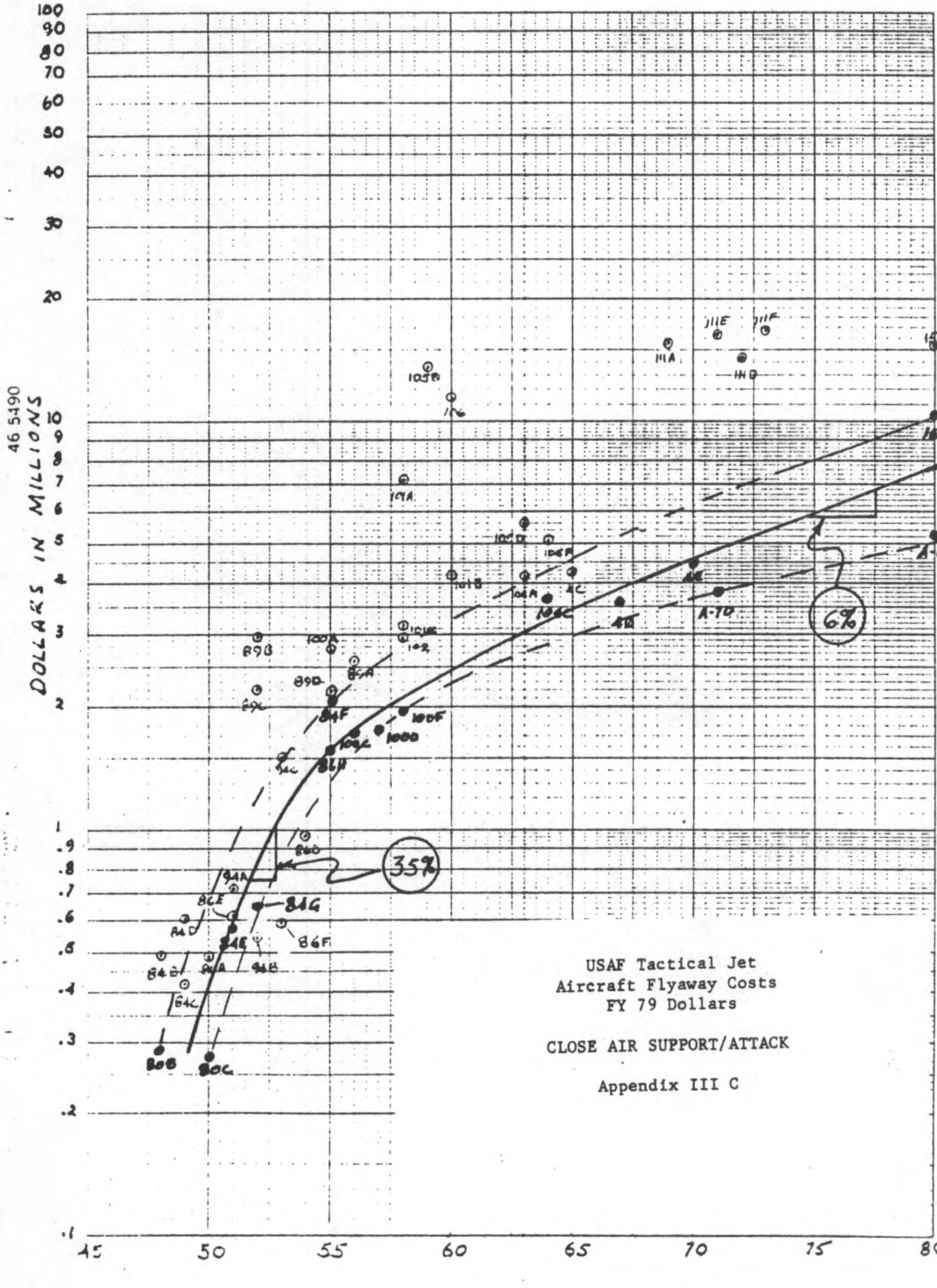




USAF Tactical Jet
Aircraft Flyaway Costs
FY 79 Dollars

AIR SUPERIORITY

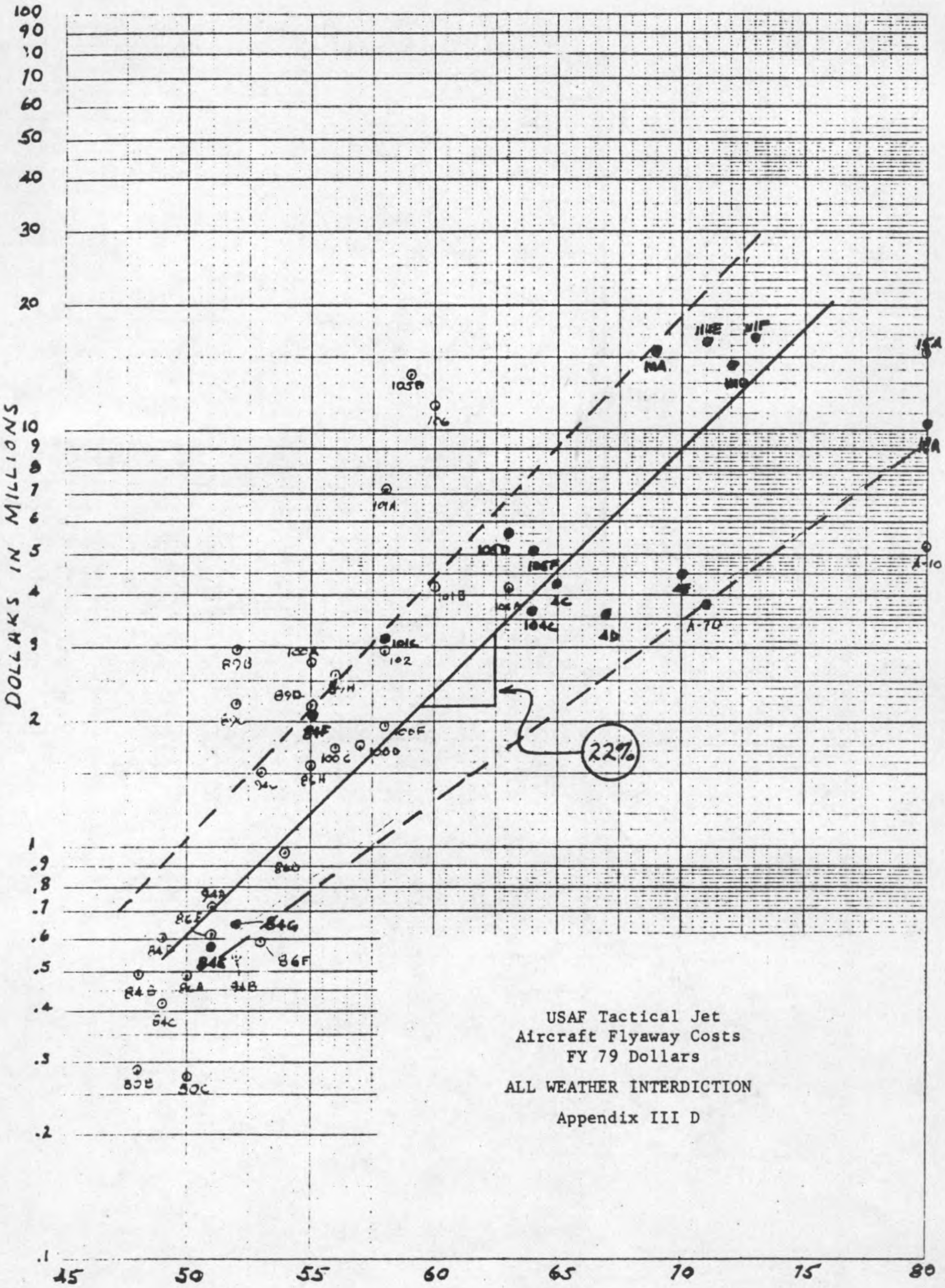
Appendix III B



USAF Tactical Jet
Aircraft Flyaway Costs
FY 79 Dollars

CLOSE AIR SUPPORT/ATTACK

Appendix III C



USAF Tactical Jet
Aircraft Flyaway Costs
FY 79 Dollars

ALL WEATHER INTERDICTION

Appendix III D

Guernica (1937) by Pablo Picasso
Extended Loan from the artist to The Museum of Modern Art, New York City, N. Y.